State of Utah
DEPARTMENT OF NATURAL RESOURCES
Division of Wildlife Resources – Native Aquatic Species

BOREAL TOAD (*BUFO BOREAS BOREAS*)

CONSERVATION PLAN

Publication Number 05-37
Utah Division of Wildlife Resources
1594 West North Temple
Salt Lake City, Utah
Jim F. Karpowitz, Director

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IN THE STATE OF UTAH

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DEFINITIONS

A **breeding population** is a collection of toads associated with one or more breeding sites, usually within the same drainage, that are not separated by dispersal barriers or distances greater than eight km.

A **breeding site** is a habitat where boreal toad eggs, tadpoles, or amplexed adults have been observed within the past ten years. To be considered a separate breeding site, an area must not share surface flow with other such areas during the breeding season, or it must be separated from other such areas by a minimum of 0.5 km.

A **dispersal barrier** is a barrier that impedes boreal toad movement among breeding sites or habitat types. Barriers may include heavily traveled roads or highways, large rivers, human residence, large expanses (>5 km) of dry habitat lacking aquatic corridors, drainage boundaries, large water impoundments, dams, and other unsuitable habitats.

A **historic habitat** is a habitat where toads were documented more than ten years ago, but have not been observed since that time. Designation as historic habitat does not necessarily mean that the habitat is unoccupied. Rather, it could mean that a habitat has not been sufficiently surveyed within the past ten years to document boreal toad presence or absence.

A **metapopulation** is a collection of toads that may regularly move among a minimum of three breeding sites, such that gene flow among breeding populations and natural re-colonization of breeding sites following local extirpations are likely. Each metapopulation breeding site should be separated from its nearest neighbor by no more than 10 km, with no intervening dispersal barriers.

An **occupied habitat** is a habitat where boreal toad eggs, tadpoles, metamorphs, juveniles, or adults have been observed during the past five years.

A **potential habitat** is a habitat where conditions appear to be suitable for boreal toad, where the presence of boreal toads has never been documented, and where multiple surveys have not yet been conducted.

An **unoccupied habitat** is a habitat where surveys have been conducted during the breeding season in at least three of the past ten years, and where boreal toads have not been observed.

EXECUTIVE SUMMARY

Utah's boreal toad (*Bufo boreas boreas*) populations have experienced declines in their populations similar to those experienced by amphibians worldwide. The recent discovery of chytrid fungus (*Batrachochytrium dendrobatidis*) in Utah has increased concern for boreal toad populations. Chytrid fungus has been implicated in the rapid declines of frog species globally and has specifically caused the decline of boreal toads in the Colorado Southern Rocky Mountains. In the western United States, the boreal toad is listed as a federally endangered species in New Mexico and is currently being petitioned for federal listing in Colorado. In Utah, the boreal toad was listed as a state sensitive species in 1995 at which time the Utah Division of Wildlife Resources (Division) began conducting surveys to determine the status of existing populations.

From surveys and monitoring efforts, the Division found previously undocumented populations and verified that a small number of boreal toad populations exist in historic habitats. This Boreal Toad Conservation Plan has been developed to define current boreal toad distributions, determine critical ecology and life history information, identify the nature and magnitude of threats, and expedite the implementation of conservation actions for boreal toad as necessary for the conservation and maintenance of the species. The goal of this plan is to maintain or restore multiple, viable breeding populations in nine of the 14 mountain ranges or geologic areas in Utah where boreal toad historically occurred. Current population information has documented eight viable breeding populations.

The boreal toad strategy includes the following recommended conservation actions: 1) Define current distribution and status, 2) Monitor distribution, population, and habitat trends, 3) Identify and reduce threats from habitat loss and degradation, 4) Identify and reduce threats from pathogens, 5) Increase understanding of boreal toad ecology, life history, and threats in Utah, 6) Restore populations in suitable historic and potential habitats, 7) Identify and reduce threats from predators. Several local and federal natural resource agencies have volunteered funding and personnel to the conservation of the boreal toad in Utah. The conservation activities outlined in this management plan will continue to be implemented as need arises and as funds become available, however, it is in the best interest of Utah's native amphibians for the immediate and steadfast application of this Conservation Plan.

INTRODUCTION

Dramatic amphibian declines have been documented worldwide (Barinaga 1990, Blaustein and Wake 1990, Phillips 1990). Although human activities have adversely impacted many species (Sadinski & Dunson 1992, Elmberg 1993, Fahrig et al. 1995; Fisher and Shaffer 1996, Lind et al. 1996), many amphibians in relatively pristine areas with little or no human disturbance have also experienced serious population declines (Weygoldt 1989, McDonald 1990, Crump et al. 1992, Semb-Johansson 1992). This pattern suggests that widespread amphibian losses may be due to both localized impacts and more pervasive threats that may include changing global conditions (Blumthaler et al. 1997, Broomhall et al. 2000) and widespread pathogens (Carey 1993, Blaustein et al. 1994a, Berger et al. 1998, Lips 1999, United States Geological Survey 1999, Fellers et al. 2001).

In North America, the most visible amphibian declines have occurred in the western United States (Corn and Fogelman 1984). Within the last 30 years, mountain yellow-legged frog (*Rana muscosa*) and Yosemite toad (*Bufo canorus*) have each declined drastically in the Californian Sierra Nevada Mountains (Bradford 1991). The majority of Cascades frog (*Rana cascadae*) populations in Oregon have been lost from recently occupied habitats (Blaustein and Wake 1990) and the California red-legged frog (*Rana aurora draytonii*) has been extirpated from approximately 70 percent of its former range (United States Fish and Wildlife Service 2000).

Boreal toad (*Bufo boreas boreas*) is another western anuran that has recently experienced serious declines throughout much of its range (Loeffler 2001). Due to the absence of populations in many historically occupied habitats, the Southern Rocky Mountain population of boreal toad in Colorado and populations in Wyoming, and New Mexico have been candidates for listing or warranted for listing as endangered under the Endangered Species Act of 1973, as amended, but precluded due to higher priorities (United States Fish and Wildlife Service 1995). Recently, the Southern Rocky Mountain population was removed as a candidate by the Fish and Wildlife Service (USFWS 2005) following a 12-month finding. The reasons for removing the boreal toad as a candidate were because the Southern Rocky Mountain population was not recognized as a species, subspecies or Distinct Population Segment. Boreal toad has been and remains listed as a state endangered species in the state of Colorado since 1993. Boreal toad is listed as Native Species Status 1 (NSS1) in Wyoming and has been listed as a state endangered species in New Mexico since 1976. In Utah, an apparent distribution decline (Ross et al. 1995) prompted the Division (1997a) to classify boreal toad as a state sensitive species. However, as of 1995, the status of the species in Utah remained largely unknown, and the extent of the perceived distribution decline was partially due to a lack of recent surveys in specific areas rather than actual population extirpations. Surveys conducted between 1995-2003 have better defined the current distribution of boreal toad in Utah (Thompson et al. 2004).

This conservation plan has been developed by the Division to: 1) refine the current distribution and status in Utah; 2) expand understanding of boreal toad ecology and life history; 3) identify the nature and magnitude of threats; and 4) expedite the implementation of conservation actions for boreal toad should they be required. This plan incorporates and utilizes information that has been obtained through research and recovery efforts in other states, and will apply successful techniques to the extent possible in Utah. This is the first iteration of the plan, and the DIVISION is the sole author with other agencies encouraged to participant.

BIOLOGICAL INFORMATION AND STATUS

SPECIES DESCRIPTION

Boreal toad is a subspecies of the western toad, a member of the family Bufonidae in the order Salientia. Bufonids generally have stocky bodies and short rear legs. Most bufonids are incapable of leaping and move instead by hopping or walking. They have horizontal pupils and rough, warty skin. A distinguishing characteristic of bufonids is the prominent paratoid gland behind each eye. When attacked by predators, these glands secrete a sticky, white poison that inflames the throat and eyes, causes nausea, and sometimes causes paralysis (Stebbins 1985). Most bufonids are nocturnal and are generalized feeders.

Figure 1. Dorsal view of an adult boreal toad in Pine Creek within the Awapa Plateau (*Photo T. Hawkes*).

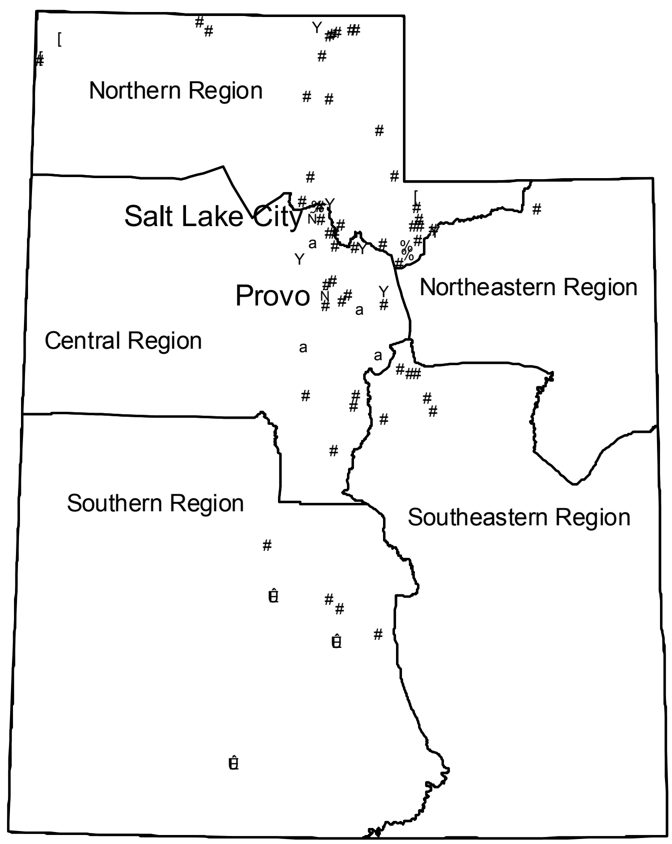
The western toad is stocky with short limbs, having a head that is narrow compared to the broad body. Dorsal coloration is variable and may be dusky gray, brown, tan, olive green, dark green, or yellow. Warts on the back and legs are often surrounded with dark blotches and tinged with a rust color (Figure 1). The chest and abdomen have dark, blotchy spots on a white background and the throat has smaller, rounded, black marks (Figure 2). The ventral surface is coated with tiny, black-tipped tubercles. There is a distinct tarsal fold on the hind feet. A yellow, cream, or pale green mid-dorsal stripe runs from the nostrils to the posterior end of the body. The mid-dorsal stripe is often absent in recently metamorphs and adult toads. The paratoid glands are large and oval and the eyes are gold-flecked with horizontal pupils. Snout vent length (SVL) of adults ranges from 62 to 128 mm. Males are typically smaller, less blotchy, and have a paler throat than females. Unlike Woodhouse toad (*Bufo woodhousei*), western toad lacks a cranial crest. Western toad can be distinguished from the Amargosa toad (*Bufo nelsoni*) by its broader head and blunter snout, longer limbs, larger feet with more webbing, and rougher skin. Within the western toad species, boreal toad can be distinguished from the California toad (*Bufo boreas halophilus*) by its narrower head, smaller eyes and feet, and heavier pigmentation. Boreal toad tadpoles are solid black and range from 27 mm to 44 mm long (Wright and Wright 1995).

Figure 2. Ventral view of juvenile boreal toad *(Photo T Hogrefe)*.

Boreal toads generally lack a vocal pouch. During the breeding season, males produce weak mating calls that resemble release calls (Karlstrom 1956, Blair 1963, Awbrey 1972). The call resembles the weak peeping of baby chicks. A single mating call sequence generally consists of 11 to 56 chirps, emitted at a rate of about seven per second (Awbrey 1972). Release calls usually consist of no more than ten chirps or pulses per sequence, emitted at a rate of about five per second (Awbrey 1972). Release calls are weak and are audible over only short distances. By contrast, mating calls have been audible at a distance of 50 meters (Awbrey 1972).

DISTRIBUTION AND STATUS

The historic western toad range included much of western North America. The California toad subspecies occurs in central and southern California, western Nevada, and northern Baja California. The boreal toad subspecies distribution extends as far north as southeastern Alaska, and includes British Columbia, Alberta, and Northwest Territory in Canada; and Washington, Oregon, northern California, Idaho, western Montana, Nevada, Utah, Wyoming, Colorado, and northern New Mexico in the contiguous United States.



\# Museum records (N = 51)
% Pre-1971 reports within reported elevation limits (N = 3)
[Tadpoles present 1992-1993 (N = 3)
Y Tadpoles present 1971-1991, not present 1992-1993 (N = 6)
ê New record exterior to historic range (N = 3)
a Adults present 1971-1991 (N = 4)

Figure 3. Documented boreal toad localities, pre 1995 (Thompson et al. 2004).

Boreal toad currently persist in all of these historic areas, with the probable exception of New Mexico. Within some of these areas, however, local boreal toad distribution has been significantly reduced. Although boreal toads were historically widespread and abundant throughout high elevation areas of Colorado, Wyoming, and New Mexico, the local distribution has contracted in recent decades. Carey (1993) observed the extirpation of 11 populations in the West Elk Mountains between 1974 and 1982. Surveys from 1982 to 1992 found boreal toads in only two of 250 historic localities in several Colorado counties (Loeffler 2001). Other surveys at 377 sites in Colorado found only one boreal toad population (Hammerson 1992). Corn et al. (1989) estimated that toads were absent from 83% of historic locations in Colorado and 94% of historic sites in Wyoming. Recent survey efforts in New Mexico have failed to identify any extant boreal toad populations (Loeffler 2001).

In Utah, boreal toad was apparently widespread and abundant historically. Tanner (1931) described it as “the common species in the canyons and mountains of central and northern Utah." Woodbury (1952) described it as a "common garden toad". Hardy (1938) wrote that it was "common in the Colorado River drainage in Sevier and Wayne counties" in southern Utah.

There are records of boreal toad occurrence at approximately 203 localities in Utah (Table 1, Figure 3). These records include information from museums, resource agency reports, and data on file at the Utah Division of Wildlife Resources. The documented distribution includes sixteen mountain ranges or geologic areas occurring throughout Utah, including the Grouse Creek Mountains, Hansel Mountains, Bear River Range, Monte Cristo Range, Wasatch Range, Uinta Mountains, Raft River Mountains, Goose Creek Mountains, Wasatch Plateau, Book Cliffs, Tushar Mountains, Sevier Plateau, Awapa Plateau, Hurricane Cliffs, Pine Valley Mountains, and Paunsagunt Plateau (Figure 4). Records indicate boreal toad occurrence in 20 of the 29 counties in Utah.

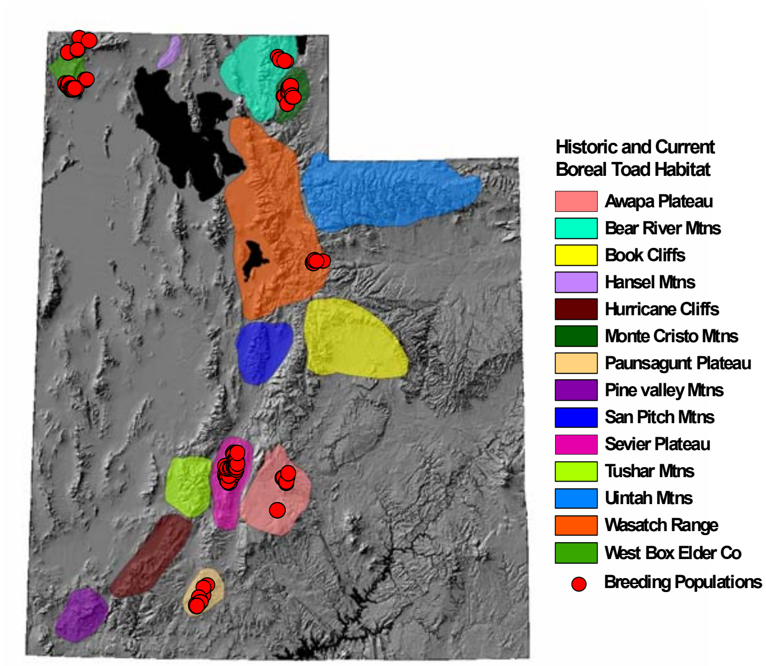


Figure 3. Documented boreal toad localities, pre 1995 (Thompson et al. 2004).

Ross et al. (1995) noted that the preponderance of historic records in northern Utah may reflect higher localized collection efforts rather than higher population densities in that area. Tanner (1931) indicated that boreal toads were commonly observed along the shores of the Great Salt Lake and Utah Lake. Ross et al. (1995) questioned the validity of these observations based on an apparent lack of suitable boreal toad habitat and museum records. Of 100 reported museum specimens collected from 51 separate localities in Utah, none were collected within 17 km of either the Great Salt Lake or Utah Lake (Ross et al. 1995).

Boreal toad populations are still distributed throughout much of the historic Utah range (Thompson et al. 2004), however, documented extant populations are irregularly distributed within the former distribution. Within the past 10 years, boreal toads have been documented in nine mountain ranges or geologic areas, including West Box Elder County, Bear River Range, Monte Cristo Range, Wasatch Range, Uinta Mountains, Sevier Plateau, Awapa Plateau, Book Cliffs, and Paunsagunt Plateau (Table 1, Figure 4). Although documented extant populations occur in only 13 Utah counties (Box Elder, Cache, Rich, Wasatch, Summit, Salt Lake, Utah, Sevier, Piute, Emery, Wayne, Garfield, and Kane) the recent discovery of additional populations indicates that boreal toad is more widespread in several mountain ranges than the historic records indicate. Since 1995, boreal toad has been observed at a minimum of 102 localities (Thompson et al. 2004). Boreal toad occurrence at the majority of these sites was documented for the first time within the past ten years (Thompson et al. 2004). It is likely that more populations will be discovered as more historic and potential habitats are surveyed.

SYSTEMATICS AND POPULATION GENETIC STRUCTURE

Systematic relationships among bufonids, including boreal toad, have been examined in several studies (Karlstrom 1956, Blair 1963, Maxson et al. 1981, Graybeal 1997). Feder (1973) used allozyme analysis to identify the four species in the current *Bufo boreas* species group, which includes Yosemite toad, black toad (*Bufo exsul*), Amargosa toad, and western toad. Graybeal (1993) inferred phylogenetic relationships among 19 species in the family Bufonidae and concluded that the *Bufo boreas* species group was monophyletic and recently evolved. Within the species group, boreal toad in the northern portion of the range comprise a monophyletic group that is separate from western toad in California, Yosemite toad, and black toad (Graybeal 1993).

Recent studies have determined genetic relationships within the boreal toad subspecies (Goebel 1996, 1997, 1998, 2000*a*). Mitochondrial DNA analyses (Goebel 1996, 2000a) and nuclear DNA analysis (Goebel 2000a) revealed substantial genetic divergence among boreal toad populations throughout the range. The mitochondrial DNA analyses identified four major clades. Populations from Colorado, Wyoming, and the Monte Cristo Range and Sevier Plateau in Utah comprised one of the major clades, as did the population from the Paunsagunt Plateau in Utah. Populations from elsewhere in Utah were not included in the analyses.

Subsequent mitochondrial DNA analysis (Goebel 2000b) identified five major groups in the southeast portion of the range, including Utah: 1) Grouse Creek Mountains (Western Box Elder County), Utah and Elko County, Nevada; 2) Caribou County, Idaho; 3) Sevier Plateau, Utah; 4) Paunsagunt Plateau, Utah; and 5) Colorado, Wyoming, New Mexico, and Sevier Plateau and Monte Cristo Range, Utah. Nuclear AFLP analysis (Goebel 2000b) also identified five major groups but their placement differed slightly from the mitochondrial DNA analysis. Whereas the mitochondrial analysis identified the Paunsagunt Plateau as a major clade, the nuclear analysis identified those samples as a minor clade within another major clade. The fifth group identified by nuclear analysis included toads from Colorado, Wyoming, and New Mexico, but not toads from Utah.

In a separate analysis, Hogrefe (2001) observed genetic relationships that were generally consistent with those identified in earlier analyses of Utah boreal toad populations (Goebel 2000b). Mitochondrial DNA and nuclear DNA analyses each identified three Utah groups: 1) Grouse Creek Mountains (Western Box Elder County); 2) Monte Cristo Range, Wasatch Range, Sevier Plateau, and Awapa Plateau; and 4) Paunsagunt Plateau. The results of Hogrefe (2001) were more consistent with the nuclear DNA analysis of Goebel (2000b), which found that the Grouse Creek Mountains populations were the most divergent in Utah. Hogrefe (2001) classified the three groups as "Conservation Units" based on the criterion of significant allele frequency differences at both mitochondrial and nuclear loci.

Molecular data suggest that gene flow among most Utah populations is extremely limited (Hogrefe 2001). Gene flow is probably precluded by the large distances and lack of migration corridors between habitats. However, in the study by Goebel (2000b), mitochondrial DNA analysis revealed that one sample from the Grouse Creek Mountains in the Snake River drainage was more closely related to samples from central Idaho than to populations in Utah. Hogrefe (2001) found that samples from the same population possessed two mitochondrial DNA composite haplotypes that were not found elsewhere in Utah. These results suggest that there has been occasional gene flow between populations in central Idaho and populations in the Snake River drainage in Utah.

Hogrefe (2001) indicated that levels of genetic variability within populations were low compared to other amphibians, likely due to a combination of founder effects and recent population bottlenecks. It is important to note the low levels of variability may limit the ability of populations to adapt to changing environmental conditions or new threats.

LIFE HISTORY AND ECOLOGY

Elevation Range

Western toad is generally considered to occupy relatively high elevation habitats compared to other western amphibians. In Colorado, the documented elevation range of boreal toad is 2,164 to 3,640 m and toads are most often observed between 2,250 and 3,600 m (Campbell 1970a, Livo and Yeakely 1997). In southeastern Wyoming, historic records previously ranged up to 3,200 m but records of current occurrence currently do not exceed 2,925 m (Livo and Yeakely 1997).

The DIVISION has records of historic boreal toad occurrence in Utah at elevations from 1,570 to 3,220 m (Thompson et al. 2004). Based on a query of museum holdings, Ross et al. (1995) found that elevation information was available for 29 of the 100 reported specimens. The elevation of the collection localities for these specimens ranged from 1,374 to 3,136 m, but Ross et al. (1995) questioned the validity of the lower elevation records based on a lack of supporting museum specimens and the absence of typical boreal toad habitat at the reported localities. The current distribution suggests that the actual historic minimum elevation of boreal toad in Utah is probably not lower than 1,570 m. Differential habitat use between the sexes has been documented in the Paunsagunt Plateau and Sevier Plateau from preliminary radio telemetry studies conducted by the US Forest Service (S. Brazier, pers. comm.)

Habitat Requirements

Although boreal toad habitats in Colorado seem to be closely associated with lodgepole pine or spruce fir forests (Campbell 1970b), occupied wetlands in Utah are surrounded by a variety of upland vegetation communities, including sagebrush and grassland, pinyon-juniper, mountain shrubs, and coniferous forest (Scott et al. 1993). Extensive observations of upland and winter habitat use in Utah have not been completed. However, toads have been observed using small mammal burrows in drier upland areas (Fridell et al. 2000). Radio-telemetry studies in Colorado indicate that toads occupy upland montane forests and rocky areas near spring seeps (Jones et al. 1998). Campbell (1970b) noted that boreal toads are relatively independent of water compared to other amphibians, but they must re-hydrate daily. In Utah, breeding habitats include low velocity, low gradient streams, off-channel marshes, beaver ponds, small lakes, reservoirs, stock ponds, wet meadows, seeps, and associated woodlands (Fridell et al. 2000, Thompson and Chase 2001).

Habitat use patterns after breeding are likely dependent on characteristics of the upland environment and may differ between the sexes (Campbell 1970b, Campbell 1976). Female toads may use habitats that are drier and more distant from breeding habitats compared to males (Jones et al. 1998). In a study of Oregon populations (Samallow 1980), males were abundant in and near water bodies throughout the warm months. Females were generally found in surrounding forested areas except during the brief breeding period. Campbell (1970b) indicated that male boreal toads in Colorado preferentially use moist areas, whereas females are more common in drier habitats. Differential habitat use between sexes has not been documented in Utah.

Currently, hibernacula in Utah have not been described. To date, only one hibernaculum was discovered in the Paunsagunt Plateau. In Colorado, Campbell (1970c) found five separate hibernacula along a stream with perennial flow. Each hibernaculum consisted of a small chamber beneath or adjacent to large boulders. A continuous flow of groundwater 1 to 4 cm beneath the chamber floor maintained hibernacula air temperatures above 0.0°C, despite ambient temperatures during winter measured as low as -31°C. The five hibernacula were used by a minimum of 30 toads during a single winter and there was apparently no mortality. Campbell (1970c) speculated that this sort of hibernaculum is probably uncommon and that most of the toads in the study area either traveled relatively long distances to find other similar hibernacula, or they used hibernacula with different characteristics. In other areas, hibernating boreal toads have been found using ground squirrel (*Spermophilus lateralis*) burrows to avoid freezing during the winter (Jones et al. 1998). Other possible hibernation sites, particularly for metamorphs, are beaver lodges and dams (Loeffler 2001).

Burrows represent critical microhabitats for boreal toad and other amphibians, especially in warmer, drier climates (Carey 1978, Smits 1984). Burrows are important for maintaining stable body temperatures despite extreme ambient temperatures (Smits 1984). Smits (1984) found that toads always remained in the deepest burrow locations during winter, resulting in relatively low and stable body temperatures. During summer, burrows may be used to prevent water loss and dehydration.

Reproduction

Initiation of boreal toad breeding appears to be correlated with the onset of warming weather and snowmelt (Blaustein et al. 2001, Blaustein et al. 2003, Campbell 1972, Corn 2003, Corn and Muths 2002, Olson 1988, Olson et al. 1986). In Utah, breeding occurs from April to July, depending on elevation and weather (Fridell et al. 2000, Thompson and Chase 2001, Thompson 2004). In the Western Box Elder County population in Utah, the onset of breeding is generally observed after breeding site water temperatures are sustained at or above 10-12°C (Thompson and Chase 2001).

During the breeding season, males actively search for females, clasp female and male toads indiscriminately, and do not defend territories (Olson et al. 1986). Olson et al. (1986) reported that males do not give mating calls and only vocalize release calls when clasped by other males. Awbrey (1972), however, was able to distinguish between mating calls and release calls.

Olson et al. (1986) observed two mating patterns at different study sites in Oregon. At one site, a large male advantage was frequently observed. At other sites, there was positive assortative mating according to size. Boreal toad may exhibit variable mating patterns in response to fluctuating environmental conditions, demographic parameters, and mating competition or sexual selection (Olson et al. 1986). Campbell (1970b) and Olson (1991) indicated that female adult toads may not breed every year.

In some explosively breeding amphibians, mating males often obtain their mates by aggressively displacing clasped males from females (Davies and Halliday 1979, Lamb 1984, Howard and Kluge 1985). Boreal toad competition for mates has been observed (Black and Brunson 1971), but displacement of clasping males seems to be rare. In a study by Olson et al. (1986), only one of 271 paired females was observed to be clasped by two males before spawning.

Time of arrival at the breeding site may be an important factor in boreal toad mate competition. Males that arrive early may have greater reproductive success due to longer breeding activity or early pairing with available females. In the study by Olson et al. (1986), early arriving boreal toad males had a greater probability of pairing with females, despite that early and late arriving males did not differ in size. A female amplexed by a male will extrude two egg strands, one from each ovary. The eggs are laid in cylindrical strands, often in a double row, with no partitions between the individual eggs (Wright and Wright 1995). The eggs are black and surrounded by a transparent, gelatinous film. Samallow (1980) estimated that females produce an average of 12,000 eggs per spawn.

Egg strands are generally laid in still, shallow water along the edges of ponds, lakes, and streams (Campbell 1972, Stebbins 1985, Nussbaum et al. 1993). Fridell et al. (2000) reported that boreal toad breeding habitat in southern Utah is characterized by little or no water current, shallow perimeters with emergent vegetation or submerged grasses, organic substrate, and gently sloping banks. Egg strands are often found entwined in vegetation in shallow water.

Lengths of egg and larval development vary with elevation and temperature. In Utah, eggs generally hatch within three weeks of deposition and tadpole development requires approximately two months on average. Reproductive efforts have failed in some Utah breeding sites because ponds have dried prior to tadpole metamorphosis (P. Thompson, personal communication).

Population Structure

Samallow (1980) estimated that a minimum of 95 to 99 percent of tadpoles and metamorphs die during the first year of life. The primary causes of mortality tend to be adverse environmental conditions and predation. Adults often live more than nine years (Hammerson 1982, Campbell 1976) and maximum life span is estimated to be about 12 years (Loeffler 2001).

The sex ratios of breeding adults were male biased at three populations in Oregon (male:female = 1.5-2.6:1.0) (Olson et al. 1986). The adult sex ratios at other Oregon breeding sites were also male biased through several years (male:female = 4.2:1.0) (Samallow 1980). However, all of these observations may not necessarily reflect a skewed sex ratio. Instead, they may reflect differing habitat utilization between the sexes (Campbell 1970b, Samallow 1980). Sex ratios have generally not been characterized in Utah. In Box Elder County Utah, sex ratios of breeding adult boreal toad also were male biased with ratios varying from 1.2-4.7:1.0 (male:female) (Thompson 2004). In other breeding habitats in Utah, higher numbers of males are usually observed as well (P. Thompson, K. Wheeler, personal communications).

Movement

Wright and Wright (1995) indicated that boreal toads are highly terrestrial and typically migrate to breeding sites, deposit egg strands, and return to upland burrows. Campbell (1970c) found that toads in a Colorado population moved 900 meters from summer habitat to hibernacula between August and October. In the spring, toads emerged from the hibernacula and returned to summer habitat. Females may typically move farther from breeding sites than males (Jones et al. 1998). To reach summer habitat, a female boreal toad in Idaho traveled 2.5 km uphill through dry forest following breeding (Bartelt 2000). In Colorado, a female toad marked at a breeding site in July was found 4 km away in the following spring (P.S. Corn, unpublished data). By contrast, males do not appear to move more than 1 km from breeding sites (Bartelt 2000, Muths 2003). However, one male boreal toad moved 5 km during one summer/fall in Utah (Thompson 2004)

In Utah, Thompson and Chase (2001) documented boreal toad movements among breeding sites in the Western Box Elder County. Of the 423 toads PIT-tagged, 232 were recaptured. Of the recaptured toads, 26 had moved 142 meters between areas at one of the breeding sites. Nine of the recaptured toads had moved approximately 1.6 km between breeding sites. Some of those nine toads had moved during the summer months, when approximately 1 km of the movement corridor was dry. Movement of a single toad between two other breeding sites separated by 0.9 km was documented in 2002 (Thompson et al., 2003). In addition, one boreal toad female moved 5.25 km between 2002 and 2004 on the Monte Cristo Mountains (P. Thompson, personal communication).

Boreal toad movement studies in Utah have focused on adults or juveniles greater than or equal to 50 mm SVL (Thompson and Chase 2001) and there are few data on metamorph movements. Adult amphibians tend to be philopatric (Oldham 1966, Breden 1987, Berven and Grudzien 1990). For example, when released 300 m away from a breeding site, boreal toads moved across dry terrain and swam across a lake to return directly to the breeding habitat from which they were captured (Tracy and Dole 1969). Given a high degree of adult site fidelity, metamorph dispersal may be the most important mechanism to re-colonize extirpated populations and colonize new habitats (Semlitsch 2002). Therefore, it is important to collect additional data to describe metamorph and subadult movement.

Boreal toad movement may be guided by celestial cues. Toads may use Y-axis orientation (Gorman and Ferguson 1970), where objects in the sky and on the horizon that intersect on a vertical axis are used to identify the direction of breeding habitats. This orientation would allow a toad to return to a breeding habitat after seasonal movements or after artificial displacements. In a study by Tracy (1971), western toads were sealed in opaque jars and released 25 km away from the breeding site from which they were captured. Under clear conditions, adults moved toward the breeding area and juveniles moved away from the breeding area. Some studies suggest that visual cues are most important for orientation (Gorman and Ferguson 1970, Tracy

1971). However, other research has indicated that blinded toads possess the ability to determine the direction of breeding habitats (Tracy and Dole 1969). In that study, olfactory cues appeared to provide the principal means of orientation.

Feeding

Boreal toads are predominately insectivorous. Stomach samples taken throughout the range include primarily ground dwelling insects (Formicidae, Carabidae, and Araenidae) as well as pine needles and other ground debris (Moore and Strickland 1954, Miller 1978). Campbell (1970b) reported that boreal toads in Colorado feed heavily on terrestrial arthropods, especially beetles, ants, and spiders.

Hailman (1984) observed that toads were most active during the late evening and early morning periods and least active during the darkest period of the night. This bimodal activity pattern may be used to optimize foraging (Hailman 1984). Campbell (1970b) noted that non-food items were more abundant in the stomachs of toads collected at night, suggesting that toads feeding in darkness miss their prey more often. Therefore, at least low levels of illumination may be important for foraging success. Shinn and Dole (1979) and Dole et al. (1981) reported that western toads are attracted to the odor of an insect species upon which they have previously fed. In the absence of visual cues, an odor alone can be sufficient to cause western toads to search for and approach the source. Moreover, insect odor can elicit feeding behavior, characterized by extrusion of the tongue.

Activity

Campbell (1970c) found that marked toads in hibernacula moved no more than 1.5 m during a winter. Most movements occurred shortly after entry in the fall and shortly before emergence in the spring. Smits (1984) found that western toads in California remained inactive in burrows from November through January. Upon emergence from hibernation, toads displayed a pattern of surface activity which included daily emergence from and return to a home burrow (Smits 1984). Time spent outside of the burrow generally increased from February to May but toads spent the most time outside of the burrow during April. In June, a switch to nocturnality occurred, and toads occupied deep burrows from early morning until shortly after sunset. Toads once again became diurnal during the cooler fall months. Smits (1984) found that juveniles emerged from dormancy earlier and terminated surface activity later in the year compared to adults.

Diurnal activity in early spring and fall may occur to optimize body temperature, maximize foraging success, and increase growth rates (Lillywhite et al. 1973, Smits 1984). Basking in direct sunlight increases body temperature and may enhance immune system functioning (Kluger 1978) and increase rates of digestion (Jorgensen 1992). Basking by breeding adults also may facilitate early breeding activity and provide the maximum amount of time for metamorphosis and juvenile growth in high elevation areas with short warm seasons (Van Oordt 1960). Smits (1984) found that surface activity of toads occurred between air temperatures of 10°C and 25°C. Voluntary maximum body temps during the spring were 28.8°C for adults and 31.5°C for juveniles.

Smits and Crawford (1984) found that the time of inversion between ambient and burrow temperatures was the best predictor of morning emergence time. Toads apparently wait to emerge until the burrow entrance is warmer than the deeper burrow locations before they emerge. Time of evening emergence may be determined by decreasing light intensity or thermal cues (Cloudsley-Thompson 1967, Smits and Crawford 1984).

POTENTIAL FACTORS AFFECTING THE SPECIES

This section describes several factors that may be adversely affecting boreal toad in Utah. Many of these factors have had detrimental effects on amphibians in general and on boreal toad elsewhere in the range. The presence and magnitude of many potential threats in Utah have yet to be determined. Additional research will be necessary to determine the factors that may be limiting boreal toad distribution and abundance.

ACIDIFICATION, PESTICIDES, AND CONTAMINANTS

Impacts to amphibians due to chronically acidified waters in northeastern North America are well documented (Schindler 1988, Freda et al. 1991, Sadinski and Dunson 1992). In western North America, though, acidic deposition is less severe, chronic acidification of aquatic habitats is relatively rare (Schindler 1988, Eilers et al. 1989, Turk and Spahr 1991), and there are relatively low levels of sulfate and nitrate deposition (National Atmospheric Deposition Program 1990). However, many high elevation waters in western North America are extremely sensitive to acidification due to low ion concentrations, tendency to be directly filled by snowmelt, thin soils, and crystalline bedrock (Eilers et al. 1989, Wissinger and Whiteman 1992).

Acid deposition is often considered as a general threat to amphibians, but specific detrimental effects to western amphibians have rarely been observed, despite habitat predispositions for acidification. The lowest observed pH for Sierra Nevada surface waters did not reduce survival of different life stages of mountain yellow-legged frog or Yosemite toad (Bradford et al. 1992). From 1982 to 1988, Wissinger and Whiteman (1992) found no evidence that survival of tiger salamander embryos or larvae was affected by pH in central Colorado. Boreal toads in Colorado and Wyoming occupy some of the most acid-sensitive habitats, but acidification rarely occurs, and only at levels insufficient to kill amphibian embryos (Schindler 1988, Corn and Vertucci 1992). Although some species breed during snowmelt when an acidic pulse could lower pH, boreal toad breeds later in the season and acidic pulses of this type usually occur before egg deposition occurs. Early boreal toad life stages appear to be more resistant to low pH than are most fish (Porter and Hakanson 1976). The LC50 pH for boreal toad eggs was found to be 4.4-4.5 (Corn and Vertucci 1992) and the lethal pH for boreal toad tadpoles range from 3.1 to 4.0 (Porter and Hakanson 1976). Low pH may not necessarily cause mortality, but it can affect development in other ways such as altering hatching size and timing (Bradford 1992), and altering food availability due to effects on the algal community (Corn and Vertucci 1992).

Pesticides can be harmful to amphibians (Berril et al. 1993). Rotenone is a non-specific piscicide that is frequently used to removed undesirable fishes from waters in western states, including Utah. Rotenone applications at typical concentrations may not seriously affect adult amphibians but would probably kill tadpoles and juvenile salamanders (California Department of Fish and Game 1985, Sousa et al. 1988). However, it is difficult to predict the effects of rotenone on any particular amphibian species because tolerances across taxa are highly variable (Hall and Henry 1992). Adult amphibians may avoid water when it becomes toxic. Although this behavior may prevent direct mortality from poisoning, it may subject amphibians to other threats such as predation and dehydration. Tadpoles cannot escape water and would experience high levels of mortality if a lethal dose was applied. The effect on hibernating adult amphibians is uncertain. The substrate and low respiratory rate may prevent mortality if a lethal concentration was applied, but there are no data to support this hypothesis. In Utah, rotenone has been applied to several historically occupied habitats, but little monitoring was conducted to determine the impacts on resident boreal toad populations.

Poisoning may also result from application of other types of pesticides that are used for forest management and animal control (Loeffler 2001). Other chemicals, including pollutants from road runoff and agriculture, can be detrimental to amphibians. Nitrogen fertilizers are frequently applied at levels that can induce mortality in several amphibian species (Marco et al. 1999). Other agricultural chemicals have been found to induce abnormalities or impair sexual development in several species (Berril et al. 1993, Hayes et al. 2002). High levels of salinity due to road runoff may affect western toad equilibrium (Dole et al. 1985).

DISEASE

Carey (1993) proposed that pathogenic infection, facilitated by environmental stress, is potentially one of the greatest factors leading to boreal toad mortality and population declines. The primary pathogen of concern for boreal toad in Utah is chytrid fungus. Although chytrid is the common name for fungi in the phylum Chytridiomycota that has one class (Chytridiomycetes) and more than 100 genera, only one species, (*Batrachochytrium dendrobatidis*) is known to be parasitic on amphibians (Fellers et al. 2001).

Most fungal populations possess high levels of genetic variation (James et al. 1999, Taylor et al. 1999), but *B. dendrobatidis* samples from widespread locations exhibited extremely low levels of genetic polymorphism (Morehouse et al.2003). Resting spores associated with sexual reproduction are common in most chytrid fungi (Sparrow 1960), but no *B. dendrobatidis* resting spore-like structures have been observed on amphibian hosts. It has been postulated that, due to the apparent lack of a resistant resting spore stage, the widespread distribution, and the lack of genetic variability, it is likely that the pathogen has been recently transported around the globe by humans involved in the pet trade and scientific research (Morehouse et al. 2003).

Chytrid fungus infection manifests itself in the outer dermal layers of frogs and other amphibians (Sredl 2000). Adult frogs infected with chytrid exhibit symptoms such as lethargy and reluctance to flee, skin abnormalities, loss of righting reflex, and extended back legs (Fellers et al. 2001, National Wildlife Health Center 2001). Healthy tadpoles generally have oral discs with keratinized jaw sheaths and tooth rows that are heavily pigmented. In tadpoles infected with *B. dendrobatidis*, these structures are abnormally formed or lack pigment. This type of deformity may inhibit tadpole foraging ability (Fellers et al. 2001). The exact mechanism that causes mortality in chytrid-infected individuals is not well understood (Sredl 2000). Potential mechanisms include disruption of water, oxygen, and ion exchange through the skin and secretion of a toxin by the fungus (Berger et al. 1998, Pessier et al. 1999). In the model proposed by Carey (1993), death may result due to infection coupled with environmental stressors that suppress the immune system. Chytrid fungus infection was first identified and implicated in amphibian declines in Central America and Australia in 1998 (Berger 1998, Lips 1999). However, the earliest records of infection were detected by examination of archived amphibian specimens collected in Colorado in 1974 (Carey et al. 1999) and in Australia in 1978 (Speare et al. 2001), suggesting that the pathogen has been present in at least some habitats for decades. In the U.S., chytrid fungus has been found in at least ten species of amphibians and has been associated with declines of boreal toad and the endangered Wyoming toad (*Bufo hemiophrys baxteri*) in Colorado, Wyoming, and New Mexico (National Wildlife Health Center 2001). Chytrid fungus infection has been documented in one population in Utah, found along the East Fork Sevier River on the Paunsagunt Plateau (Thompson et al. 2004), and is the suspected cause of several mortalities observed in recent years (K. Wheeler, personal communications).

Amphibians are susceptible to infection from pathogens other than chytrid fungus. The bacterium *Aeromonas hydrophila* is present in many environments and can cause red-leg disease in amphibians. A pathogen, described as iridovirus, has been responsible for salamander deaths throughout the western United States and Canada (Jancovich et al. 1997, United States Geological Survey 1999). Blaustein et al. (1994a) identified the spread of a pathogenic fungus (*Saprolegnia ferax*) that appears to be largely responsible for egg mortality in a boreal toad population in Oregon. *Saprolegnia* is commonly carried by fish (Seymour 1970, Richards and Pickering 1978) and may be introduced to amphibian habitats via sport fish stocking (Kiesecker et al. 2001). Once introduced to a system, individual amphibians may transmit the pathogen to other populations as they migrate or disperse.

FIRE

Fires can directly affect boreal toad populations by causing direct mortality and local extirpations. The long-term effects of fire may be more severe now than in the past because many habitats have been recently fragmented due to human activities and climate change, and natural re-colonization may no longer be possible. The ongoing drought in Utah has increased the incidence and severity of forest fires in recent years, which may increase the frequency of local extirpations.

Fire also impacts boreal toad by immediately degrading and fragmenting habitat. Fire may result in degradation of water quality, as ash and debris are washed into aquatic systems during rain storms. Changes in the vegetative community may either adversely impact or benefit toad populations. Burning of downed woody materials approximately 18 to 25 cm dbh is detrimental to boreal toads, because these materials are often selected as beneficial microhabitats (Loeffler 2001). However, fire may eventually result in higher shrub densities in the understory (Loeffler 2001) that may provide cover and improved dispersal corridors.

HABITAT FRAGMENTATION

Gene flow among mountain ranges probably occurred at low levels during the recession of Lake Bonneville, between 16,800 and 10,000 years ago when a cold, moist climate provided many aquatic corridors (Rhode and Madsen 1995). During this period, boreal toad in Utah were likely able to use both low and high mountain passes for interbasin movement (Hovingh 1997) and the proximity of aquatic sources to drainage boundaries probably facilitated toad migration among regions. However, during the past 10,000 years, Utah has become warmer and drier (Antevs

1948), aquatic corridors have been lost, and populations in different mountain ranges have likely become isolated. Genetic data suggest that migration among mountain ranges has not occurred for thousands of years (Hogrefe 2001).

As a result of this climate change, boreal toad in Utah currently occupies aquatic habitats that are often separated by large distances with few water sources between them. Additionally, boreal toad occupies high elevation habitats and gene flow with other habitats may require movement through lower elevation areas. Many potential low elevation corridors have been fragmented by human development and are unsuitable for dispersal.

Large migration distances and a lack of migration corridors between populations may threaten the long-term viability of boreal toad in Utah by preventing re-colonization of habitats when local extirpations occur. Small, isolated populations are more susceptible to permanent extirpations due to stochastic events, human impacts, and other environmental factors (Soulé 1987, Begone et al. 1990). Lack of gene flow may cause loss of genetic variability due to random genetic drift (Wright 1931) and inbreeding depression may occur in small, isolated populations (Franklin 1980). Reduced genetic variability reduces the adaptive potential of species forced with environmental changes.

LIVESTOCK GRAZING

Poorly managed livestock grazing causes degradation of bank condition, reduction of riparian vegetation, and acceleration of spring succession. Livestock grazing also adds excess nutrients and degrades water quality. Trampling by livestock may be a significant source of mortality for all amphibian life stages, especially for tadpoles and metamorphs that lack mobility and congregate near water margins. Livestock grazing may cause slower amphibian growth rates due to a diminished prey base and it may lower reproductive success due to alteration of water temperature, water chemistry, and habitat structure (Reaser 1996). Many of these impacts may occur in several occupied boreal toad habitats in Utah.

Wetland habitats are frequently altered by damming or dredging water sources to make them more suitable for livestock access. These modifications usually result in higher concentrations of livestock around wetlands, especially in arid western habitats. Although livestock impacts may be intensified in these areas, stock pond development can increase the amount of quiet water containing shallow areas of emergent vegetation. In Utah, boreal toads are regularly observed breeding in several of these areas, and stock pond development may have actually increased the amount of suitable toad breeding habitat (Thompson 2004).

Livestock grazing may contribute to spring succession by trampling banks and making wetland habitats more shallow, but it is possible that it may also reverse or slow succession by controlling vegetation that would otherwise overtake and congest certain types of spring habitats (P. Thompson, personal communications). Properly managed grazing could potentially benefit toad habitat in this manner. However, the optimal level and frequency of grazing for most areas in Utah have not been determined.

PREDATION

In adult bufonids, toxic skin secretions are effective repellents to some predators (Flier et al. 1980, Brodie and Formanowicz 1987). However, many animals are not deterred by this defense and boreal toads have many native predators, including common raven (*Corvus corax*) (Olson 1989, Corn 1993), gray jay (*Perisoreus canadensis*) (Beiswenger 1981), predaceous diving beetle larvae (*Dytiscus sp.*) (Livo 1998), western garter snake (*Thamnophis elegans*) (Arnold and Wassersug 1978), tiger salamander (*Ambystoma tigrinum*) (Hammerson 1982), and several other terrestrial vertebrates (Jones et al. 1999, Jones and Stiles 2000).

Nonnative species such as raccoons (*Procyon lotor*) are also boreal toad predators (Jones et al. 1999). Documented declines of western toad in California's Great Central Valley have been associated with the introduction and spread of nonnative bullfrogs (*Rana catesbeiana*) (Fisher and Shaffer 1996). The mechanism of exclusion by bullfrogs could include competition or predation on various boreal toad life stages. Mosquitofish (*Gambusia affinis*) does not currently occur in boreal toad habitats, but it is widespread within the historic distribution. If introduced into occupied habitats, this species could pose a significant threat to boreal toad because it is a known predator on amphibian eggs and larvae (Grubb 1972) and it may selectively prey on amphibians despite the availability of other potential prey items (Goodsell and Kats 1999).

The threat posed by introduced, predaceous sport fish to ranid frogs is well documented (Zardus et al. 1977, Bradford 1989), but the threat to bufonid frogs may not be as serious. The threat of fish predation would primarily occur during the egg and larval stages, but boreal toad eggs and tadpoles are toxic or distasteful to most predators (Brodie and Formanowicz 1987, Hews 1988). Even in the absence of other food, trout avoided eating boreal toad tadpoles in a Colorado hatchery (Jones et al. 1999).

Boreal toads may be especially susceptible to predation during breeding (Olson 1989, Corn 1993) because they are concentrated and relatively visible compared to other times of year. Adult boreal toads exhibit several behaviors that may reduce predation risk during this period. Males may release females during breeding to avoid predators (Olson 1989). However, communal breeding, communal oviposition, and explosive breeding seasons may reduce the predation risk to adult boreal toads through dilution of predator effects (Hamilton 1971, Kagarise Sherman 1980).

Boreal toad tadpoles also exhibit several behaviors to avoid predation by aquatic predators. Western toad tadpoles show an alarm reaction to chemicals exuded by injured conspecifics where they increase their activity and avoid areas containing the chemical cues (Hews and Blaustein 1985, Hews 1988). Chemicals released by conspecifics tend to elicit stronger responses than those released by different species. Tadpoles in large, dense aggregations (Nussbaum et al. 1983) may also protect themselves from predation by synchronizing metamorphosis and potentially satiating predator populations (Arnold and Wassersug 1978).

Metamorphosing toads are probably more vulnerable to predation than earlier or later life stages due to decreased mobility. Arnold and Wassersug (1978) found that transforming anurans, including boreal toad, predominated in all snake (*Thamnophis elegans* and *T. sirtalis*) stomach samples ranging from Mexico to Washington, whereas tadpoles were relatively rare.

RECREATION

Humans frequently congregate near water bodies for recreation activities, including camping, fishing, hiking, biking, and off-road vehicle use. When conducted in riparian areas, these activities can cause direct mortality of eggs, tadpoles, and metamorphs due to trampling or vehicle impacts. Additionally, recreation activities can degrade bank conditions, degrade water quality, and increase the abundance of ravens, jays, raccoons, skunks (*Mephitis spp.*), and other potential amphibian predators that are attracted to human refuse. Human movement among water bodies may also facilitate the transfer of pathogens among boreal toad populations.

Upland habitats may also be degraded through recreation activities including skiing, hiking, and off-road vehicle use. Road, trail, and slope construction for these activities may fragment and degrade suitable upland habitats and dispersal corridors. These activities may also attract predators due to deposition of refuse and human waste. Several recreational activities and facilities may occur in or near historic or currently occupied habitats in Utah.

RESIDENTIAL AND COMMERCIAL DEVELOPMENT

Many boreal toad populations in Utah occur in remote, high elevation habitats that currently face little threat from commercial or residential development. However, development has occurred in and near several historic habitats where boreal toad populations presumably no longer persist (Thompson et al. 2004). Several potential and historic habitats along the Wasatch Front have been developed as ski resorts or high-priced housing. Many areas in Utah, particularly along the Wasatch Front, are experiencing rapid rates of human population growth (Lee 2001), and continued development in high elevation areas near urban centers is anticipated.

ROADS

Worldwide, road and traffic densities have increased substantially during the past three decades (United Nations 1992). Roads have detrimental impacts to amphibian habitats and dispersal and traffic may be a cause of significant mortality and population depletion (Fahrig et al. 1995). Roads fragment habitats and may prevent migration among different habitat types and subpopulations. Roads degrade adjacent habitats by altering patterns of water flow, patterns of root propagation, and vegetation communities (Loeffler 2001). Other detrimental factors associated with roads, including pollutants, exhaust emissions, vibrations, and noise, may also affect anuran densities either by causing direct mortality or interrupting behavior (Buchanan 1993). In Utah, roads pass through many historic and occupied boreal toad habitats, and several mortalities due to vehicle impacts have been observed (Fridell et al. 2000, T. Hogrefe, personal observation).

TIMBER HARVEST

There have been several detrimental impacts to amphibians associated with timber harvest activities. The southern torrent salamander (*Rhyacotriton variegatus*) and the tailed frog (*Ascaphus truei*) have been adversely impacted by logging (Bury and Corn 1988, Welsh et al. 2000). Petranka et al. (1993) found that clearcutting strongly depletes local populations of salamanders and reduces local species richness in Appalachian forests. Many boreal toad populations in Utah occur in forest habitats, and timber harvest could have significant population impacts (Corn and Bury 1989, Dodd 1991).

Amphibians can be directly killed by felled trees and heavy machinery used during timber harvest. Tree removal and logging activities can also cause several habitat impacts. Tree removal often causes water temperatures to increase, which may reduce egg and larval survival. Even partial removal of stream canopy can increase water temperature and decrease relative humidity along riparian corridors (Bury and Corn 1988, Welsh and Lind 1996). Disturbance of hillslope and riparian soils due to logging can cause increased sediment delivery to aquatic systems (Nakamoto 1998), which may decrease the depth and availability of pools (McIntosh et al. 1993) and increase turbidity (Burns 1972). Alterations of surface water flow and subsurface runoff may result in increased peak storm flows (Wright et al. 1990) that could wash out eggs and tadpoles or bury them under sediments (Lisle 1989). Removal of timber from riparian areas decreases the amount of large woody debris that provides diverse habitat structure and refugia. Soil compaction and road construction associated with timber harvest can impact toad habitat by reducing live root systems, altering local hydrology, and destroying hibernacula.

Clearcutting has direct detrimental impacts to amphibian populations. Clearcutting degrades forest floor microhabitats for terrestrial amphibians by reducing shading, reducing leaf litter, increasing soil surface temperature, and reducing soil-surface moisture (Bury 1983, Ash 1988, Raphael 1988, Welsh 1990). Therefore, clearcuts may represent significant dispersal barriers due to lack of moisture and increased temperatures within exposed areas (Loeffler 2001).

Timber harvest can also have some beneficial effects to amphibian populations. Tree removal may increase small mammal densities and consequently increase burrow availability (Loeffler 2001). Nakamoto (1998) suggested that logging may benefit salamanders in the short term because increased scouring due to higher peak flows will transport sediment downstream and increase interstitial space between cobbles.

ULTRAVIOLET RADIATION

Anthropogenic degradation of atmospheric ozone (Stolarski et al. 1992) may be causing an increase in levels of solar ultraviolet-B (UV-B; 290-315 nm). There is some evidence for recent UV-B increases in relatively undisturbed temperate latitudes (Blumthaler et al. 1997) and progressive increases at lower latitudes are anticipated (Worrest and Grant 1989, Zurer 1993).

Amphibians may be particularly sensitive to changes in atmospheric conditions, including changes in levels of UV radiation (Blaustein et al. 1994b, Corn 1998). Their skin is not protected by hair or feathers and their eggs lack protective outer shells. By depositing strings of eggs in shallow water, boreal toad may be especially susceptible to effects of increased UV-B radiation (Corn 1998).

Worrest and Kimeldorf (1976) observed that enhanced UV-B radiation caused developmental abnormalities and mortality of boreal toad tadpoles as they approached metamorphosis. Boreal toad tadpoles exposed daily to high levels of UV-B radiation developed anomalous, concave curvatures of the spine, and abnormally thick and pigmented corneas at early stages of development. The radiation damage to the dorsal surface of the tadpoles was severe and the survival rate was reduced. Although this study demonstrates potential impacts of high levels of UV-B radiation, Corn (1998) cautions that the ecological relevance of the experiment is uncertain, because tadpoles were continuously exposed to UV-B radiation levels that were much higher than those observed in natural systems.

Other work suggests that UV radiation may decrease reproductive success in natural systems. Blaustein et al. (1994b) found that boreal toad and Cascades frog in Oregon showed significantly lower photolyase levels compared to Pacific treefrog (*Hyla regilla*). Photolyase is an enzyme that repairs damage due to UV radiation exposure. In field experiments, hatching success of embryos exposed to UV radiation was significantly greater in Pacific treefrog than in boreal toad or Cascades frog. Moreover, boreal toad hatching success increased by 50 percent in habitats shielded from UV-B radiation. Kiesecker and Blaustein (1995) reported similar increases in hatching success of toad embryos shielded from radiation at the same sites in the following year.

Not all studies, however, have demonstrated detrimental impacts from UV-B radiation (Grant and Licht 1995, Blaustein et al. 1996). UV-B exposure did not appear to influence boreal toad hatching success in Colorado (Corn 1998), suggesting that UV-B radiation may not be contributing to observed population declines in the southern Rocky Mountains.

Effects of UV-B radiation have not been determined in Utah. However, in Utah, habitat elevations are considerably lower and UV-B radiation levels are probably less than in Colorado. Therefore, it is likely that UV-B radiation is having less of an impact in Utah than it is in Colorado, where UV radiation is not perceived to be a significant threat (Corn 1998).

WATER MANAGEMENT

Water management projects have frequently had detrimental impacts on amphibian populations, especially in the arid areas of the western United States. Impacts due to water management include: 1) direct loss of habitat; 2) habitat fragmentation; and 3) detrimental alteration of natural hydrologic regimes.

Direct loss of habitat is caused by a variety of projects, including draining or filling of wetlands, water diversion for municipal or agricultural purposes, and inundation due to dam construction and reservoir filling. Dams and large reservoirs may represent impassable barriers to boreal toad movement and thereby bisect a previously connected boreal toad metapopulation. Areas that have been de-watered due to wetland destruction or water diversion may also represent barriers to toad dispersal.

Stream channelization and bank stabilization may cause the loss or degradation of suitable riparian habitats. Indirect effects due to this sort of activity may include decreased sediment retention, water quality degradation, and loss of the natural hydrologic processes that create oxbows and flooded wetlands (Loeffler 2001). Projects that alter natural hydrologic regimes could significantly decrease rates of reproduction and recruitment due to increased egg, larval, and metamorph mortality (Semlitsch 2002). Projects that unnaturally reduce the hydroperiod of wetlands may not allow sufficient time for development and metamorphosis prior to pond drying. Conversely, projects that artificially lengthen the hydroperiod of wetlands can also threaten amphibian populations by allowing increased densities of invertebrate predators and the colonization and establishment of predaceous fishes.

In Utah, reservoir construction has likely inundated historic boreal toad habitats in several areas. Wetland losses have occurred throughout the state (Lee 2001) and are expected to continue. However, it should be noted that the majority of wetland impacts will likely occur in valleys with dense human populations and agriculture, rather than potential boreal toad habitats at higher elevations.

REGIONAL POPULATION INFORMATION

The following habitat descriptions include currently occupied boreal toad habitats and some historic habitats.

WEST BOX ELDER COUNTY

Extant populations occur in the Goose Creek, Raft River, and Grouse Creek mountains in west Box Elder County. Prior to 1995, there were few records of boreal toad occurrence in this area, and range maps for the species prior to this time (e.g. Stebbins 1985) typically do not include this area as part of boreal toad distribution. Since 1995, boreal toads have been observed in 19 habitats (Table 1). Elevations for recent toad observations range from 1,570 to 1,981 m.

Boreal toad habitat consists of natural springs, springs that have been diked to create stock ponds, low gradient streams, and reservoir margins. Upland vegetation consists of pinyon pine (*Pinus spp.*), juniper (*Juniperus spp*), and sagebrush (*Artemisia spp.*), and desert grassland species. The diking of several springs for livestock watering purposes has created larger amounts of suitable breeding habitat (Thompson 2004), consisting of quiet water with shallow areas of emergent vegetation. The majority of breeding sites occur on public lands, either owned by the U.S. Bureau of Land Management or the State of Utah. A smaller proportion of lands is under private ownership.

At seven sites where intensive surveys have been conducted, a minimum of 853 individual toads (>50 mm SVL) were observed in 1999 and 2000 (Thompson and Chase 2001). Toads appear to be present in higher densities around breeding sites compared to other regions. Although this difference could reflect larger population sizes, it could also reflect a greater tendency for toads in this region to congregate around wetlands after the breeding season due to a lack of moist, forested upland habitats.

Breeding generally occurs in late March thru May (Thompson 2004), depending on when water temperatures are first sustained at or above 10-12°C (Thompson and Chase 2001). Tadpoles are observed from April through July, and metamorphs are first observed in middle to late July. Great Basin spadefoot toad (*Spea intermontana*) is the only other amphibian species observed during recent surveys besides boreal toads.

There are few obvious threats in occupied habitats and populations appear to be stable and secure. There is no apparent source of pesticides or contaminants. Symptoms and mortality due to pathogenic infection have not been observed. Most breeding sites are devoid of fish and predation mortality by other terrestrial species has been observed by a Kingfisher at a single site (P. Thompson, personal communications). Recreational use and traffic on the two-track roads adjacent to breeding sites is minimal. In this remote, unpopulated area of Utah, there is little risk from residential or commercial development. Furthermore, many breeding sites are on public lands not subject to that form of degradation. The upland habitats generally consist of sagebrush and grassland communities rather than forest, and timber harvest is not a threat. Accordingly, the threat from fire is minimal compared to other forested habitats. The water management that has occurred has actually increased the amount of breeding habitat. However, at least one breeding site has annually dried close to or prior to tadpole metamorphosis in recent years. The potential effects of acidification or increased UV-B radiation have not been determined, but they do not appear to be affecting reproduction or recruitment.

Population isolation due to a lack of dispersal corridors may be a significant threat to some breeding populations in this region. Movement among breeding sites has been documented in some areas (Thompson and Chase 2001, Thompson 2004), but many sites are fragmented by large expanses of dry terrain lacking aquatic corridors. For that reason, re-colonization of some breeding sites after potential extirpations is unlikely.

Another apparent threat to boreal toad in this area is livestock grazing. Cattle and sheep often congregate around breeding sites because they represent a large proportion of the water available in the area. Bank trampling is severe, riparian and adjacent upland vegetation is reduced, and water quality may be compromised by excess nutrients at some sites. Dead sheep have also been found in some breeding sites, locally compromising water quality. Metamorphs concentrate around the margins of the breeding sites shortly after metamorphosis, and trampling by livestock may be a significant source of mortality. However, the increase in suitable breeding habitat size due to stock pond maintenance may partially mitigate the negative effects of livestock grazing. In addition, the Bureau of Land Management has recently removed livestock from the Keg Springs Allotment, which contains many boreal toad breeding localities.

HANSEL MOUNTAINS

One historic record for boreal toad exists in the Hansel Mountains. Currently, no extant populations of boreal toad have been documented in this area. The elevation of this historic record is 4600 feet. Boreal toad can occur at this elevation but it is 550 feet lower than the lowest current observation in Utah (Thompson 2004). This record was verified as *Bufo boreas* in 2004.

BEAR RIVER RANGE

Although there are several records of historic boreal toad occurrence in the Bear River Range, the only documented extant populations in this region were discovered after 1998. Since 1995, boreal toads have been observed in six habitats (Table 1). Breeding activity was first documented in this range in 2002 and three breeding sites currently have been identified (Thompson et al. 2003, Thompson and Chase 2003, Thompson et al. 2004). Approximate elevations for recent toad observations range from 2,000 to 2,500 m.

Occupied habitats in this region consist of springs, stock ponds, low gradient stream margins, and off-channel ponds and marshes with shallow areas of emergent vegetation. Upland habitats consist of coniferous forest, mountain shrub, pinyon-juniper, and sagebrush and grassland communities. Occupied habitat occurs on both private lands and public lands managed by the U.S.D.A. Forest Service (USFS).

A small number of toads have been observed in this region since toads were discovered in 1999. Additional surveys are required to document the extent of boreal toad distribution, to identify breeding sites, and to estimate toad abundance relative to other areas.

All the factors that may negatively affect boreal toad populations and habitat in this region have yet to be defined, but at least a few threats are obvious. First, livestock grazing has degraded several riparian areas near occupied habitat. Bank conditions, riparian vegetation, and water quality are unsuitable for boreal toad in these areas. The USFS recently fenced in two of the boreal toad breeding localities in this range, however (Thompson and Chase 2003). In other areas, potential predators, such as brown trout (*Salmo trutta*) and Bonneville cutthroat trout (*Oncorhynchus clarki utah*) are present in high numbers in or near occupied habitats. Frequent angler use in these areas could induce mortality due to trampling and facilitate the transfer of pathogens. Some occupied habitats occur on forested public lands that may be subject to impacts from fire or timber harvest. Impacts to toads must be considered and minimized prior to logging. There is a minor risk of residential or commercial development in or near occupied habitats.

At this time, there is no evidence that other factors are a problem for boreal toad in this region. The population has not been monitored for sufficient time to detect potential impacts from pathogenic infection. The effects of contaminants, pesticides, acidification, or increased UV-B radiation have not been determined, but there is no initial indication that they are serious threats.

MONTE CRISTO RANGE

Extant populations occur on the Monte Cristo Range on either side of the Cache County and Rich County border. Since 1995, toads have been observed in 23 separate habitats (Table 1). Elevations for recent toad observations range from 2,316 to 2,615 m.

Most documented breeding sites consist of springs that have been diked for use as stock ponds. Toads have also been observed along the marshy outflows of these ponds and the margins of low gradient streams. In Rich County, upland habitats consist of coniferous forest and mountain shrub communities, interspersed with sagebrush and grassland communities. In Cache County, upland habitats consist of sagebrush and grassland communities. As in the Box Elder County subunit, water in this area is limited, and the diking of several springs for livestock watering purposes has created larger amounts of suitable breeding habitat. Breeding sites occur on both private lands and public lands managed by the USFS.

Compared to the Box Elder County, relatively few toads are generally observed at habitats in this area. However, breeding activity is regularly documented at most breeding sites each year. Breeding occurs later compared to Box Elder County populations, due to higher elevation and later snowmelt. Breeding generally occurs in May and June but vehicle access to some breeding sites is usually obstructed by snow until early July. Tadpoles are observed from June through August, and metamorphs are first observed in early August. Tiger salamanders are sympatric with boreal toads in several breeding sites.

There are a few visible, likely minor, threats to boreal toad populations and habitat in this region. High numbers of sheep often congregate around breeding sites in July and August. This livestock activity has denuded banks of vegetation, degraded bank condition, increased turbidity, and degraded water quality at several sites. The USFS recently fenced in one of the boreal toad breeding localities in this range, however (Thompson and Chase 2003). Some documented breeding sites are devoid of fish, but Bonneville Cutthroat Trout occur in other documented occupied stream habitat. Potential boreal toad predators, including tiger salamanders and western garter snakes, have been observed in high densities in and around breeding sites. A two-lane, paved road occurs within three km of the closest breeding sites but the magnitude of this road as a barrier is undetermined. The traffic on this road is sparse, and probably does not cause high rates of mortality. Dirt roads pass in close proximity to several breeding sites, and are used frequently by off-road vehicles when conditions permit. Runoff from these roads may compromise water quality. Several occupied habitats occur on forested public lands that may be subject to impacts from fire or timber harvest. However, impacts to toads would likely be considered and minimized prior to logging. Water management has created more breeding habitat by diking springs, but water levels decline toward the end of metamorphosis in some sites. At least one pond is regularly de-watered during annual periods of tadpole metamorphosis (P. Thompson, pers. comm.).

Other potential factors are not considered to be threats at this time. Mortality due to pathogenic infection has not been observed. There is no apparent source of pesticides or contaminants. There is little risk of residential or commercial development in or near occupied habitats. The potential effects of acidification or increased UV-B radiation have not been determined, but are not suspected to be serious threats at this time.

WASATCH RANGE

There are more records of historic boreal toad occurrence in the Wasatch Range than for any other mountain range in Utah (Table 1, Figure 5). Ross et al. (1995) suggested that the high number of records for this region may reflect relatively high collection levels near human population centers. Even so, it is likely that this area historically represented one of the highest concentrations of boreal toad in Utah. The documented current distribution has been severely reduced from historic levels. Three boreal toad were observed at different localities in Little Cottonwood Canyon between 1997-1998, but breeding sites have not been located in this canyon. Surveys resumed at Strawberry Reservoir in 2001 and 30 adults were observed near the reservoir in 2003, however, breeding has not been documented since 1997 (Thompson et al. 2004) even though juveniles have been encountered. The occupied habitats are all found at approximately 2,540 m.

Occupied habitats consist of low gradient stream margins, off-channel ponds, and marshes. Little is known about timing of reproduction in these habitats, but tadpoles were observed in July 1997. Upland habitats consist of coniferous forest and mountain shrub communities, interspersed with sagebrush and grassland communities. Occupied habitats occur on both private lands and public lands managed by the USFS. Tiger salamanders and chorus frogs (*Pseudacris maculata*) were observed in occupied boreal toad habitats, and are locally abundant throughout the area.

Additional surveys will be necessary to evaluate threats, but there are some obvious factors that may be limiting boreal toad distribution or abundance in occupied habitats. Wetland habitats near the reservoir margin may be suitable breeding habitats, but a highway isolates them from suitable upland habitat. This highway may be an impassable barrier to toads, and could detrimentally alter patterns of seasonal habitat use. Highway runoff may also flow directly into potential breeding habitats near the reservoir, potentially degrading water quality. The reservoir and associated tributaries are popular recreation areas, and highway vehicle traffic, off-road vehicle use, camping, and fishing may all have detrimental impacts to toad populations. Native and nonnative sport fish occur in occupied habitat and pose a potential predation risk. Tiger salamanders are abundant, and they could limit successful reproduction through predation on eggs or tadpoles. Livestock grazing occurs in surrounding areas, but was not observed in the occupied habitats. Forested habitats are susceptible to fire, but timber harvest is unlikely due to frequent human use for recreation. Population monitoring will be necessary to identify any effects from pathogenic infection. The potential effects of acidification or increased UV-B radiation have not been determined, but are not suspected to be serious threats at this time.

SEVIER PLATEAU

Even though there are few historic records of boreal toad occurrence in this region, the Sevier Plateau currently is one of the highest documented occupied areas in Utah (Thompson et al. 2004). Historically, few surveys were conducted in this region. Since the early 1990s, extensive surveys have been conducted, and toads have been found in most potential habitats. Boreal toads appear to be widespread in the area, and anticipated surveys are expected to document additional populations. Since 1998, boreal toad has been observed at a minimum of 28 different sites, and breeding activity has been observed in most of these habitats. Elevation of these sites range from 2,852 to 3,459 m.

Occupied habitats in this region include reservoir margins, lake margins, marshes, wet meadows, beaver ponds, low gradient, braided streams, and diked stock ponds. Many breeding habitats have dense shrubs and willows and shallow areas of emergent vegetation. Upland habitats consist of coniferous forest and mountain shrub vegetation communities. Most occupied and potential habitats occur on lands managed by the USFS but a small number of habitats occur on private land.

Relatively high numbers of toads are observed in this region compared to several other areas. Smaller numbers of toads are observed at breeding sites in the Sevier Plateau compared to the Western Box Elder County, but this may not indicate that the populations are smaller. Toads probably do not remain in breeding habitats for extended periods in this region because suitable upland habitats and dispersal corridors are available. For that reason, toads are probably detectable at breeding sites for smaller amounts of time in the Sevier Plateau compared to the relatively arid Western Box Elder County.

Eggs are typically deposited in June, but vehicle access to breeding sites during this period is often impeded by snow. Tadpoles are usually observed in mid July and metamorphs are observed in early August. Chorus frogs and tiger salamanders have been observed in several occupied boreal toad habitats.

The primary threats in the Sevier Plateau are livestock grazing, timber harvest, fire, and recreation. Livestock grazing occurs in or near the majority of habitats and has caused severe detrimental impacts in some breeding sites. Impacts include degradation of bank conditions, loss of riparian vegetation, degradation of water quality, and potential mortality of several life stages due to trampling. Timber harvest has frequently occurred and is scheduled to occur in or near several occupied habitats. In the past, logging has directly impacted toad habitats in this region. In the future, it is probable that buffers will be maintained between breeding sites and logging activities. Fire is a serious threat to boreal toad in this region. The area is heavily forested, and drought conditions have increased the incidence and intensity of fires. A fire recently destroyed occupied habitat along a stream only one year after a resident toad population was discovered. Off-road vehicle use occurs in or near several breeding sites.

Other threats include roads, predation, development, and water management. Dirt roads often occur in close proximity to breeding sites and runoff could degrade water quality. These roads may also act as dispersal barriers and cause mortality due to vehicle impacts. Bonneville cutthroat trout occur in some occupied habitats and may pose a small predation risk. It is likely that the construction of several reservoirs in the area inundated historic toad habitats. However, toads appear to be breeding along the margins of some of these reservoirs and these activities may have not caused a net loss of habitat. However, the dams that retain water probably represent dispersal barriers in some areas. Residential and commercial development is a minor risk because some habitats occur on private property. However, development pressure is relatively low compared to other areas of high population growth, such as the Wasatch Front. Mortality due to pathogenic infection has not been observed. Pesticides, contaminants, and ultraviolet radiation have not yet been identified as threats.

AWAPA PLATEAU

One occupied habitat in the Awapa Plateau has been monitored since the early 1990s, and several additional occupied habitats were identified in 2000 and 2001. In 2001, toads were observed in nine separate habitats. There are many other potential habitats in this region, and anticipated surveys may document additional populations. Elevation of documented occupied habitats range from 2,926 to 3,528 m.

Occupied habitat in the Awapa Plateau consists of meandering stream channels, lake margins, reservoir margins, wet meadows, inactive beaver ponds, and marshes. Upland habitats consist of coniferous forest and mountain shrub vegetation communities. Occupied habitats occur entirely on lands managed by the USFS.

Relatively high numbers of toads have been observed in recently discovered sites. Breeding activity has rarely been observed in this region. Although one occupied habitat had been monitored for several years, signs of reproduction were observed for the first time in 2001. Eggs, tadpoles, or amplexed toads have not been observed in the other occupied habitats identified in 2000 and 2001. However, several small juvenile toads were observed, indicating that reproduction had occurred successfully in 1999 or 2000.

Threats in the Awapa Plateau are not well documented. Livestock grazing is one potential problem. The single documented breeding site has been fenced, but moderate livestock impacts have recently been observed within the enclosure. Other occupied habitats are grazed, but the detrimental impacts are relatively small. Recreation may be a concern. Toads have been observed in close proximity to a campground and many occupied habitats are commonly used by anglers. Sport fish may pose a minor predation threat. Residential and commercial development is not considered to be a threat in these remote, high elevation habitats. Pesticides, contaminants, or UV radiation have not been identified as threats at this time. Population monitoring will be necessary to identify symptoms or mortality due to potential pathogenic infection.

PAUNSAGUNT PLATEAU

Boreal toad in the Paunsagunt Plateau were discovered for the first time in 1994. Range maps produced prior to that time (e.g. Stebbins 1985) generally do not include the area as part of the boreal toad distribution. Since 1998, boreal toads have been observed in 12 separate habitats. Elevation of occupied habitats range from 2,743 to 2,814 m.

Occupied habitats in this region include beaver pond complexes, shallow marsh areas, reservoir margins, oxbows, low gradient stream margins, small, artificial impoundments, and wet meadows. All breeding sites are associated with active beaver dam complexes, characterized by shallow perimeters, little emergent vegetation, and little to no current. Riparian vegetation is dominated by willow (*Salix spp.*), Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), and native wire grass (*Juncus balticus*). Upland habitat consists primarily of coniferous forest communities, interspersed with mountain shrub communities. Occupied habitats occur on lands managed by the USFS.

Toads are observed along several miles of the East Fork Sevier River corridor, but generally in low numbers. Egg deposition generally occurs in June and tadpoles are visible from June through July. Northern leopard frogs occur in most occupied habitats.

The principle threats to boreal toad on the Paunsagunt Plateau are livestock grazing, timber harvest, and pathogenic infection. Livestock graze in or near several breeding sites and there are severe impacts in some of these areas. Areas adjacent to occupied habitats were logged historically to the extent that native stands of Engelman spruce (*Picea engelmannii*), blue spruce (*Picea pungens*), and Douglas fir (*Pseudotsuga menziesii*) have been cleared and replaced with ponderosa pine (*Pinus ponderosa*) (Robinson et al. 1998). Future timber harvest will probably occur, but buffers will likely be maintained between occupied habitats and logging activities. Chytrid fungus infection has been documented in occupied habitats in the Paunsagunt Plateau. During the past few years, several dead toads with skin conditions symptomatic of chytrid infection have been observed at several sites. This infection may eventually cause serious die-offs and populations should be closely monitored.

Other threats include roads, predation, and recreation. A dirt road runs along the entire length of the riparian corridor. Traffic on this road has caused toad mortality and runoff may degrade water quality. Sport fish occupy the river corridor and may pose a minor threat. Western garter snakes are abundant in occupied habitats and may also represent a predation threat. Northern leopard frogs are abundant in occupied habitats, but potential effects from competition are undetermined. The area is often used for camping and fishing. These activities may attract predators and facilitate the spread of chytrid fungus among occupied habitats or to populations in other areas. Residential and commercial development, pesticides, contaminants, and UV radiation have not been identified as threats.

UINTA MOUNTAINS

Several records of historic boreal toad have been documented in the Uinta Mountains, however, very few populations have been documented in this region until 2002 (Thompson et al. 2003, Thompson et al. 2004). Since 1995, seven populations have been observed (Table 1). Breeding has been documented in four of these populations. Approximate elevations for recent toad observations range from 2,350 to 2,850 m. Occupied habitats in this region consist of streams, beaver ponds, off channel ponds, and marshes with shallow areas of emergent vegetation. Upland habitats consist of coniferous and aspen forests and grassland communities. Occupied habitats occur mostly on public lands (USFS), however, one population occurs entirely on private land.

Tadpoles were observed at two of these populations, one in 1996 and one in 1997. No adult or juvenile boreal toad were observed in this region between 1996 to 2001. In 2002, however, adult boreal toad were observed in four of the five populations with 66 toads being observed during one visit to the Yellow Creek population (Thompson et al. 2003). Additional surveys are required to document the extent of boreal toad distribution, to identify breeding sites, and to estimate toad abundance relative to other areas.

There are a few, yet relatively minor threats to boreal toad populations and habitat in this region. Limited livestock grazing and wildfire are two minor threats to this region. Bonneville cutthroat trout occupy three of the breeding sites. Non-native trout have not been documented in boreal toad breeding populations. Three boreal toad were observed near the Whitney Reservoir area, where non-native trout occur, however, breeding sites devoid of fish exist in this area. Dirt roads pass in close proximity to several of the breeding sites, and are used frequently by off-road vehicles during certain times of the year. Runoff from these roads, however, will not likely compromise water quality. Four of the seven known occupied habitats occur on forested public lands that may be subject to impacts from fire and timber harvest. However, impacts to toads would likely be considered and minimized prior to logging. Other potential factors are not considered to be threats at this time. Mortality due to pathogenic infection has not been observed. There is no apparent source of pesticides or contaminants. There is little risk of residential or commercial development in or near occupied habitats. The potential effects of acidification or increased UV-B radiation have not been determined, but are not suspected to be serious threats at this time.

BOREAL TOAD CONSERVATION STRATEGY

CONSERVATION GOAL AND ACTIONS

Goal

The goal of this plan is to maintain or restore multiple, viable breeding populations in nine of the 14 mountain ranges or geologic areas in Utah where boreal toad historically occurred. A breeding population may be considered self sustaining when breeding, recruitment, and multiple age classes have been observed at a minimum of three breeding sites per mountain range or geologic area in three of the past five years and when the breeding populations or habitat face no significant and imminent threats.

Conservation Actions

To achieve the goal of the plan, several conservation objectives have been identified. The actions desribed in this strategy directly address these objectives:

1. Define current distribution and status (Surveys).
2. Monitor distribution, population, and habitat trends (Monitoring).
3. Identify and reduce threats from habitat loss and degradation (Habitat Management).
4. Identify and reduce threats from pathogens (Disease Management).
5. Increase understanding of boreal toad ecology, life history, and threats in Utah (Research).
6. Restore populations in suitable historic and potential habitats (Range Expansion).
7. Identify and reduce threats from predators (Non-native Control).

Although this plan is designed to determine and improve the status of boreal toad, it may also benefit other native Utah species. By reducing threats and improving habitats for boreal toad, conditions may also improve for sympatric populations of northern leopard frog (*Rana pipiens*), boreal chorus frog (*Pseudacris triseriata*), tiger salamander, Great Basin spadefoot toad (*Spea intermontana*), speckled dace (*Rhynicthys osculus*), and the Utah species of concern, Bonneville cutthroat trout, Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*), leatherside chub (*Gila copei*), and other sympatric reptiles, mammals, birds, and invertebrates.

SURVEYS

Surveys conducted during the past ten years have yielded important information regarding the current boreal toad distribution in Utah. Some surveys have documented the absence of boreal toad in several historic habitats (Ross et al. 1995). During that same period, several populations have been re-discovered in historic habitats or discovered in previously undocumented areas (Ross et al. 1995, Fridell et al. 2000, Thompson and Chase 2001, Thompson et al. 2003, Thompson et al. 2004). However, some historic habitats have not been re-surveyed in decades, and other areas containing potential habitat have never been surveyed. Therefore, additional efforts are necessary to further define the current distribution and current status of boreal toad in Utah. As these surveys are conducted, habitats within the historic range will be evaluated for reintroduction or introduction activities.

Target survey areas should include historic habitats and other potential habitat types, including streams, beaver ponds, small lakes, reservoirs, stock ponds, marshes, wet meadows, seeps, and associated woodlands (Fridell et al. 2000, Thompson and Chase 2001). Potential habitats can be identified using U.S. Geological Survey (USGS) 7.5 minute topographical maps, mapping software, aerial photographs, and field observations. Survey areas should generally occur in areas above 1600 m. Apparently suitable sites not indicated on maps should be surveyed as encountered.

Breeding site surveys and visual encounter surveys (Crump and Scott 1994) will be the principal techniques used to define boreal toad distribution. The primary objective of these surveys will be to determine boreal toad presence or absence. Therefore, the surveys will not necessarily be constrained by time. However, time constrained surveys may be used in conjunction with mark-recapture studies to determine population sizes as part of population monitoring (See Monitoring Plan). Even though surveys will not be constrained by time, the amount of time spent searching and the number of crew members should be recorded.

Breeding site surveys are conducted by walking along wetland perimeters, scanning for amphibians, eggs, or tadpoles. Slow, deliberate movements are recommended when walking through dense vegetation at wetland margins. This behavior will maximize amphibian observation and also prevent amphibian injury due to trampling. Unless there are large shallow expanses of emergent vegetation, it is generally not necessary or advisable to walk in the water. Wading decreases water clarity, obscures tadpoles and egg strands, and could cause amphibian injuries (Loeffler 2001).

Visual encounter surveys should be conducted in wet meadows or large shallow expanses of emergent vegetation. Crew members should walk parallel transects at 2 m intervals, scanning for amphibians within one meter of either side of a transect line. Alternatively, parallel transects may be walked in a zig-zag pattern to achieve complete visual coverage of an area. Visual encounter surveys for boreal toad may be conducted at two levels of intensity. Surveys at the lower intensity level involve counts of animals visible on the surface only. Many amphibians may go undetected at this level, but it prevents habitat destruction and potential amphibian injury due to overturning surface objects such as rocks and logs. Surveys at the higher level of intensity involve counting animals on the surface as well as animals discovered due to overturning surface objects. This intensity level usually yields higher numbers of observed amphibians, but should be used only when the corollary impacts to habitat or a resident population are not a serious concern.

Survey timing and frequency is important. To detect toad presence, a potential habitat could be surveyed on three or more separate occasions during a single year. The first survey should be conducted when adult toads are likely to congregate around and deposit egg strands in breeding habitats. The timing of this activity varies by elevation and area, but generally occurs when snow has melted around breeding areas and water temperatures are sustained at or above 10-12 °C (Thompson and Chase 2001). A second survey should be conducted when eggs hatch and tadpoles may first be visible, generally one to two weeks after egg deposition. The third survey should be conducted immediately prior to or during tadpole metamorphosis, approximately two months after hatching, dependent on temperature. Surveys conducted during these periods will maximize the chances of detecting a boreal toad population at a site. If it is possible to visit a site only once in a given year, then the survey should occur during the time of year, the time of day, and weather conditions when amphibians will most likely be detected (Crump and Scott 1994). A habitat may be considered to be unoccupied when surveys have been conducted during the breeding season in at least three of the past ten years and no boreal toad life stages have been detected.

A standardized amphibian survey data sheet (Appendix 1) should be completed for every survey. Survey, habitat, and faunal information should be included on each data sheet. Survey information includes date, time, crewmember names, weather conditions, Universe Transverse Mercator (UTM) coordinates, site name, and survey methods. Habitat information includes ambient and water temperatures, water chemistry data, habitat type and size, dominant vegetation, bank type and condition, and maximum and mean water depth. When amphibians are detected, the species and observed numbers of each life stage should be recorded. Snout vent length (mm) measurements, weight (g), and sex should be recorded for each detected juvenile and adult boreal toad. Age class and water depth of the egg strands should also be recorded. To document occurrence, crew members should photograph all observed boreal toad life stages at occupied habitats, especially upon the first observation of boreal toad in an area. Data sheets and photographs should be submitted for data entry at the end of each field season. Dead toads found during surveys should be preserved according to protocols specified in the Disease Management section and Appendix 2.

The following equipment may be necessary for amphibian surveys, habitat descriptions, and tissue collection:

Camera, cooler with ice, data sheets, dip nets (large and small), ethanol (95 %), formalin (10%), GPS device, hip boots, metric ruler, metric thermometer, nylon measuring tape, pencils, Pesola spring balance, pH meter, scintillation vials, water chemistry probe, whirlpaks or ziploc bags, disinfectant for boots and gear.

1.0. Surveys

1.1 Define historic boreal toad distribution.
1.1.1 Compile locality records from museums, gray literature, primary literature and data on file.
1.1.2 Develop, maintain, and update a distribution database.
1.1.2.a Include historic and current localities.
1.1.2.b Include zero data from surveys.
1.1.3 Estimate the extent of historic boreal toad distribution in Utah.

1.2 Define the current Utah boreal toad distribution.
1.2.1 Re-survey historic habitats.
1.2.2 Develop survey priorities for areas containing potential habitat.
1.2.3 Survey potential habitat.

1.3 Describe habitat conditions.
1.3.1 Record occupied habitat parameters during distribution surveys.
1.3.2 Identify threats during distribution surveys.
1.3.3 Determine the availability of dispersal corridors among habitats.

1.3.4 Determine suitability of unoccupied habitats for range expansion.

MONITORING PLAN

Documented extant boreal toad populations in Utah have been monitored for several years or since their discovery during recent surveys (Fridell et al. 2000, Thompson and Chase 2001). To this time, however, monitoring objectives and methodology have varied according to crew and geographic area. This section establishes standardized statewide monitoring protocols that should be followed by all field crews. Standardization of objectives and methodology will allow data comparison across populations and assessment of statewide trends. The principal objectives of monitoring are to estimate population sizes, to track population trends, and to identify and evaluate changing habitat conditions.

2.0 Population and habitat monitoring

2.1 Monitor population trends.
2.1.1 Conduct three, time constrained searches.
2.1.2 Document age class structure during breeding surveys.

2.2 Describe habitat conditions.
2.2.1 Record habitat parameters during population monitoring.
2.2.2 Identify general threats during population monitoring.
2.3.3 Evaluate general habitat responses to conservation actions and/or threats.

HABITAT MANAGEMENT

There are several potential threats to boreal toad habitat in Utah, including fire, fragmentation, livestock grazing, pesticides and contaminants, recreation, residential and commercial development, roads, timber harvest, and water management. The magnitude of some specific threats are not well understood and additional research is necessary to determine the best management and mitigation techniques. The cooperation of federal land management agencies, state agencies, and private landowners will be critical to the protection of boreal toad habitats. This section identifies habitat research projects and also offers habitat management guidelines to land managers based on the best available data. These guidelines will be updated and revised as more information becomes available.

3.0 Habitat Management

3.1 Fire Management.
3.1.1 Protect habitats in forest stands adjacent to and within 2.5 miles of breeding sites.
3.1.2 Restrict burns to late fall through early spring during which time boreal toads are inactive in known occupied areas.
3.1.3 Determine impacts of fire through monitoring of known breeding sites.
3.2 Habitat Fragmentation.
3.2.1 Prevent further habitat fragmentation of breeding populations.
3.2.1.a Identify and preserve dispersal corridors.
3.2.1.b Identify and preserve metapopulation structure.
3.2.2. Restore historic dispersal corridors where possible.
3.2.2.a Identify where migration and gene flow among occupied habitats should be facilitated.

3.2.2.b Improve habitat conditions in degraded dispersal corridors where appropriate.
3.2.2.c Remove dispersal barriers where appropriate and feasible.
3.3 Livestock Grazing
3.3.1 Determine and implement livestock grazing regimes that are beneficial or minimally destructive to boreal toad populations.
3.3.1.a Prevent mortality of all life stages due to trampling.
3.3.1.b Prevent grazing impacts during the period from egg deposition to metamorphosis.
3.3.1.c Minimize depletion of boreal toad prey base.
3.3.1.d Minimize degradation of bank conditions.
3.3.1.e Minimize degradation of water quality.
3.3.1.f Minimize depletion of emergent and riparian vegetation.
3.3.1.h Construct fences to exclude or redirect livestock where necessary.
3.4 Pesticides and Contaminants.
3.4.1 Identify presence and impacts of pesticides and contaminants in representative occupied and potential habitats.
3.4.2 Eliminate or reduce impacts of pesticides and contaminants.
3.5 Recreation
3.5.1 Eliminate or reduce camping impacts.
3.5.1.a Work with groups in heavily used camping areas containing boreal toad breeding sites to educate users to minimize impacts.
3.5.1. Regularly contain and remove human refuse to avoid attracting predators.
3.5.2 Eliminate or reduce hiking and off-road vehicle impacts.
3.5.2.a Maintain buffers of at least 50 m between breeding sites and new trails.
3.5.2.b Prohibit off-road vehicle use within 50 m of wetland and riparian areas.
3.5.2.c Close off-road vehicle trails within 50 meters of breeding sites where feasible
3.5.3 Reduce angler impacts.
3.5.3.a Discourage angler use of breeding habitats through the use of fences and signs.
3.5.3.b Encourage anglers to disinfect equipment between uses in different water bodies.
3.6 Residential and Commercial Development
3.6.1 Prevent loss of boreal toad habitat and dispersal corridors due to development.
3.6.1.a Protect habitats on private land through conservation easements and acquisition.
3.6.1.b Encourage local, state, and federal land use planning that minimizes impacts to boreal toad populations and habitat.
3.6.1.c Prevent wetland destruction due to development.
3.6.2 Maintain buffers between boreal toad habitat and areas of development.
3.6.2.a Maintain buffers on private land through conservation easements and acquisition.
3.6.2.b Designate Areas of Critical Environmental Concern, Special Interest Areas, Research Natural Areas, and Wildlife Management Areas on federal and state lands containing boreal toad populations.

3.7 Roads
3.7.1 Minimize dispersal barriers posed by roads.
3.7.1.a Install culverts and bridges to allow for natural riparian zones and stream flows where possible.
3.7.1.b Avoid developing new roads that bisect occupied toad habitat.
3.7.2 Minimize detrimental habitat impacts due to roads.
3.7.2.a Direct road runoff away from breeding habitats.
3.7.2.b Maintain buffers of at least 150 m between breeding sites and new dirt roads.
3.7.2.c Maintain buffers of at least 1.0 km between breeding sites and new paved roads.
3.7.2.d Maintain buffers of at least 4.0 km between breeding sites and new highways.
3.8 Timber Harvest
3.8.1 Protect habitats in forest stands adjacent to and within 4.0 km of breeding sites.
3.8.2 Restrict timber harvest to late fall through early spring during which boreal toads are inactive in known occupied areas.
3.9 Water Management
3.9.1. Prevent habitat fragmentation associated with water management.
3.9.1.a Prevent large water impoundments and canals in occupied boreal toad habitat.
3.9.1.b Prevent de-watering of dispersal corridors due to water diversion or impoundment.
3.9.1.c Prevent filling or draining of wetlands between occupied habitats.
3.9.2 Minimize habitat loss and degradation associated with water management.
3.9.2.a Minimize stream channelization.
3.9.2.b Minimize de-watering of habitat due to diversion or impoundment.
3.9.2.c Minimize inundation of occupied habitat due to large dam and reservoir construction.
3.9.2.d Avoid breaching stock pond dikes that provide breeding habitat.
3.9.2.e Minimize filling or draining of wetlands due to agricultural, residential, or commercial development.
3.9.3 Create, restore, and maintain new habitats through water management.
3.9.3.a Create shallow shoreline margins in new impoundments.
3.9.3.b Deepen impoundments to maintain sufficient water levels through metamorphosis.
3.9.3.c Create new wetlands according to boreal toad breeding habitat requirements.

DISEASE MANAGEMENT

Chytrid fungus has been implicated in severe boreal toad die-offs elsewhere in the range (Loeffler 2001), and poses a potential significant threat to boreal toad in Utah. To date, chytrid fungus infection has been documented in one population on the Paunsagunt Plateau (Thompson et al. 2004) and is suspected to be the cause of recent mortality in this population. Chytrid fungus will be the primary focus of disease management for boreal toad, but risks from other pathogens will also be addressed. Disease management actions include:

4.0. Determine the health status of wild populations.

4.1.1 Conduct testing to identify the presence of chytrid fungus and other relevant pathogens in boreal toad populations or habitat.

4.1.2 Determine the extent of infection in populations.

4.1.3 Monitor effects of pathogenic infection on each life stage.

4.2 Prevent transmission of pathogens among populations.

4.2.1 Implement field disinfection protocols.

4.2.2 Prevent unauthorized transportation and release of amphibians among water bodies.

4.2.3 Encourage anglers to disinfect equipment between movements among water bodies.

4.3 Identify and minimize factors that exacerbate effects of pathogenic infection.

4.3.1 Identify environmental factors that may suppress immune systems, compromise health, and promote mortality.

4.3.2 Eliminate or reduce detrimental factors to the extent possible.

4.4 Develop and maintain captive refugia for infected populations, as necessary.

4.4.1 Identify populations at risk of extirpation due to pathogenic infection.

4.4.2 Develop a separate captive refugium for each threatened population.

4.4.3 Treat infection in captive toads with Itraconazole or other appropriate agent.

4.5 Test for pathogens prior to introduction into new habitats.

4.5.1 Test boreal toads for pathogenic infection prior to transfer.

4.5.2 Test other amphibian species at the introduction site for pathogenic infection.

4.5.3 Conduct introductions only when amphibians from source and recipient populations are not infected with pathogens of concern.

Specimen collection for disease testing will be conducted according to the protocols outlined by Converse and Green (2001) (Appendix 2).

To prevent the transmission of pathogens among populations, biosecurity protocols outlined by Converse and Green (2001) (Appendix 2) will be followed. Converse and Green (2001) recommend using bleach to disinfect equipment but a product called Quat-128 (Waxie Sanitary Supply product) at a 1:100 solution may be used instead. Quat-128 does not damage field gear as bleach does but should be rinsed off hands after contact.

Populations in which chytrid fungus has been identified should be monitored regularly to track the potential effects of infection. Adults should be checked for signs of infection immediately upon emergence and after first onset of cold temperatures in the fall. Mortality should be monitored periodically throughout the summer. Tadpole infection can be diagnosed by examining oral disks with a 10x hand lens.

RESEARCH

Prior research conducted in other states provides useful information about life history, threats, and management techniques, but additional research is necessary to collect information specific to Utah populations. Although many life history characteristics are undoubtedly shared throughout the range, boreal toad populations in Utah occupy a wide variety of habitat types that differ from populations found elsewhere. Additionally, effects of certain environmental factors may vary among geographic regions.

Mark-recapture studies

Mark-recapture studies involve the capture, marking, release, and subsequent recapture of animals within a prescribed study area. Mark-recapture studies can provide population size estimates, as well other information, including demographic parameters, patterns of habitat use, and growth rates (Donnelly and Guyer 1994). Mark-recapture studies will be completed on select populations in Utah as needed.

Time constrained surveys

Indices of toad abundance can be developed by relating the number of toads or egg strands observed during time constrained searches to population size estimates obtained from mark-recapture studies. Time constrained searches will then be sufficient to compare toad abundance through time and among sites.

Similar to distribution surveys, monitoring searches will consist of breeding site surveys and visual encounter surveys (Crump and Scott 1994). For these techniques, monitoring will be conducted in the same manner as surveys (See Survey section), with one exception. Whereas the principle objective of surveys is to determine toad presence or absence, monitoring seeks to determine changes in population sizes. Therefore, monitoring searches will be constrained by standardized search times and effort to allow comparison of data among sites and through time. Additionally, intensity level of searches should be standardized for all sites. All searches should be performed at the lower level of intensity, where only animals visible on the surface are counted, and surface objects are not overturned.

Search times for each breeding habitat will be determined by habitat size and complexity. Ideally, annual time constrained searches should be conducted under the same weather conditions and with the same level of expertise.

Time constrained searches should be conducted weekly during the period when egg deposition is occurring. Searches should be conducted during daylight hours to facilitate detection of obscure egg masses, tadpoles, and other early life stages. Numbers of each life stage observed during each visit should be recorded. To prevent counting a single egg strand more than once, a sketch indicating the location of each egg strand should be completed for each site visit. If necessary, individual egg strands may be flagged, but caution should be used to not attract predators. Individual egg strands are usually distinguishable from each other, but several egg strands are occasionally deposited in close proximity (Thompson and Chase 2001). If it is not possible to distinguish individual egg strands in a cluster without damaging them, then the cluster should be counted as a single strand. If tadpoles are already present during the first visit of a year, then separate tadpole clusters may be considered to have hatched from separate strands only in early stages of development. Tadpole development and survival should be monitored at two-week intervals until metamorphosis is completed.

A standardized amphibian survey data sheet (Appendix 1) should be completed for every monitoring survey. Monitoring survey, habitat, and faunal information should be included on each data sheet. Survey information includes date, time, crew member names, weather conditions, UTM coordinates, site name, and survey methods. Habitat information includes ambient and water temperatures, water chemistry data, habitat type and size, dominant vegetation, bank type and condition, and maximum and mean water depth. When amphibians are detected, the species and observed numbers of each life stage should be recorded. Snout vent length (mm) measurements, weight (g), and sex should be recorded for each detected juvenile and adult boreal toad. Age class and water depth of the egg strands should also be recorded. Crew members should also photograph boreal toad life stages. Data sheets and photographs should be submitted for data entry at the end of each field season. Dead toads should be preserved according to protocols specified in the Disease Management section and Appendix 2.

The following equipment may be necessary for mark-recapture studies, visual surveys, habitat descriptions, and tissue collection:

camera
cooler with ice
data sheets
dip nets (large and small)
ethanol (95 %)
formalin (10%)
GPS device
hip boots
metric ruler
metric thermometer
disinfecting agent for boots/gear
nylon measuring tape
pencils
Pesola spring balance
pH meter
PIT tags (Biomark TX1400L)
PIT tag implanter (Biomark MK-5/125)
scintillation vials
surgical scissors
water chemistry probe
whirlpaks or ziploc bags

5.0 Research

5.1 Determine habitat use by season and life stage.
5.1.1 Identify suitable breeding habitat, upland habitat, and hibernacula conditions for each life stage.
5.1.2 Quantify habitat availability and limiting habitat factors.
5.1.3 Determine seasonal patterns of habitat use for each life stage.
5.1.4 Characterize the availability of suitable dispersal corridors.
5.1.5 Document population responses to habitat degradation, manipulation, creation, and restoration.
5.2 Characterize population structure and toad movements.
5.2.1 Estimate population size.
5.2.1a Conduct mark-recapture studies at selected breeding sites throughout Utah to estimate population sizes.
5.2.1.b Conduct time constrained searches at the same selected breeding sites.
5.2.2 Track boreal toad movements.
5.2.2a Track toad movements to characterize upland habitat use and movement among breeding sites.
5.2.2.b Document colonization of new habitats.
5.2.2.c Document re-colonization of habitats after extirpation or disturbance (e.g. fire, flood).

5.3 Determine life history and demographic parameters.
5.3.1 Determine length of tadpole development and percent of survival through metamorphosis.
5.3.2 Determine longevity and age-specific mortality.
5.3.3 Quantify variability in fecundity with age.
5.3.4 Determine age at sexual maturity.
5.3.5 Determine frequency of female egg deposition.
5.3.6 Determine if multiple paternity of egg strands occurs.
5.3.7 Quantify the success of egg development, tadpole development, and recruitment.
5.3.9 Determine boreal toad diet.
5.4 Investigate UV radiation, contaminant and pesticide related impacts.
5.4.1 Compare historic and current UV radiation levels in Utah habitats, if possible.
5.4.2 Compare current UV radiation levels to those in Oregon and Colorado.
5.4.3 Compare hatching and developmental success at multiple levels of UV radiation.
5.4.4 Determine habitat use by season and life stage.
5.4.5 Determine pesticide and contaminant related impacts to boreal toad populations.
5.5 Quantify the effects of livestock grazing.
5.5.1 Compare boreal toad abundance, reproduction, and recruitment at multiple grazing intensities through experiments or observational studies.
5.5.2 Compare habitat conditions and stability at multiple grazing intensities through experiments and observational studies.
5.5.3 Identify the mechanism(s) by which grazing may be impacting boreal toad populations.

RANGE EXPANSION

The goal of this plan requires multiple viable metapopulations in nine of the 14 mountain ranges or geologic areas where boreal toad occurred historically in Utah. Boreal toad populations have been recently documented within seven of these areas, but metapopulation structure has yet to be determined. Upcoming distribution surveys will likely discover additional populations in several areas, and it is possible that the goal may be achieved without artificial range expansion. However, extensive fragmentation among local habitats and among mountain ranges will likely preclude the re-colonization of many currently unoccupied habitats. If surveys reveal that the current distribution does not include a sufficient number of viable metapopulations and natural colonization of new habitats is unlikely, then translocation may be necessary. Exact translocation needs will be determined when surveys have satisfactorily defined the current distribution. Aside from range expansion purposes, propagation may be conducted to develop and maintain captive refugia for populations that are at risk of extirpation due to serious and persistent threats.

6.0 Develop range expansion protocols
6.1 Identify translocation, broodstock, and captive refugia needs.
6.1.1 Identify appropriate broodstock sources for captive propogation and translocation.
6.1.2 Determine the number and location of populations to be established via translocation.
6.1.3 Identify threatened populations for which captive refugia are necessary.

6.2 Develop, test, and implement propagation techniques.
6.2.1 Construct or develop a toad propagation facility.
6.2.2 Develop and test toad husbandry techniques.
6.2.3 Propagate and maintain toad brood stocks at an appropriate facility.
6.2.4 Maintain separate brood stocks according to genetic identification and source population.
6.3 Develop and test translocation methodology.
6.3.1 Develop methodology for translocation.
6.3.2 Conduct experimental translocations.
6.4 Establish new populations via translocation.
6.4.1 Determine habitats suitable for toad introduction or reintroduction.
6.4.2 Stock suitable life stage(s) from appropriate brood stocks.
6.4.3 Monitor survival of each life stage.
6.4.4 Monitor long-term success of translocation.

NONNATIVE CONTROL

Several terrestrial and aquatic species are potential boreal toad predators and high rates of mortality due to predation have been observed elsewhere in the range (Olson 1989, Corn 1993, Jones et al. 1999). The magnitude of the predation threat in Utah is largely unknown. Mass predation has not been observed, but such events may be occurring undetected outside of annual survey periods. The presence or abundance of potential predators near boreal toad habitats has generally not been documented. Therefore, additional research is necessary to determine how predators may be affecting boreal toad in Utah. Until more information becomes available that may warrant otherwise, measures will be taken to prevent the introduction of potential predators into occupied boreal toad habitats and to control potential nonnative predators where necessary. Predator management actions include:

7.0 Nonnative control
7.1 Identify where nonnative predation adversely impacts populations.
7.1.1 Identify the presence and abundance of nonnative predators in boreal toad habitats.
7.1.2 Quantify the extent of non-native predation on boreal toad populations.
7.2 Prevent introduction of nonnative fishes into boreal toad habitats.
7.2.1 Prevent stocking of predaceous sport fish in boreal toad habitats in accordance with the State of Utah Policy for Fish Stocking and Transfer Procedures (Utah Division of Wildlife Resources 1997b).
7.2.2 Prevent stocking of mosquitofish (*Gambusia affinis*) into boreal toad habitats in accordance with a memorandum of understanding between the Utah Division of Wildlife Resources and local Utah Mosquito Abatement Districts.
7.3 Reduce or eliminate predation where necessary.
7.3.1 Develop and test methods to control predators.
7.3.2 Implement methods to control nonnative predators where necessary.

Table 1. Site name, hydrologic subunit (USGS 1974, county, and year of last reported observation for documented boreal toad localities within associated mountain ranges in Utah.

Mountain Range	Site Name	Hydrologic Unit	County	Last Reported Observation
W. Box Elder County	Camp Creek	16020308	Box Elder	1996
	Cedar Spring	16020308	Box Elder	2005
	Cluster Springs	16020308	Box Elder	1998
	Coal Mine Spring	16020308	Box Elder	2005
	Cotton Creek	16020308	Box Elder	1999
	Etna Reservoir	16020308	Box Elder	1993
	Red Butte Creek	16020308	Box Elder	1998
	Head of Etna Creek 2.5 mi north of Etna	16020308	Box Elder	1942
	Lower Rocky Pass Spring	16020308	Box Elder	2005
	Lynn Reservoir	17040210	Box Elder	1999
	Mud Basin Spring	16020308	Box Elder	2005
	No Name Spring	16020308	Box Elder	2005
	Puckett Spring	16020308	Box Elder	2005
	Raft River	17040210	Box Elder	1998
	Ensign Ponds	16020308	Box Elder	2005
	Rosebud Creek	16020308	Box Elder	1992
	unnamed spring	16020308	Box Elder	2001
	Upper Rocky Pass Pond #1 & #2	16020308	Box Elder	2005
	Upper Rocky Pass Pond #3	16020308	Box Elder	2005
	Wildcat Creek	17040210	Box Elder	2003
	Willow Spring	16020308	Box Elder	2005
	Willow Spring (above Coal Mine Spring)	16020308	Box Elder	2001
Hansel Mountains	Snowville	16020309	Box Elder	1928
Bear River Range	3 MI East of Garden City Bear Lake	16010201	Rich	1950
	3 MI South of Paradise	16010203	Cache	1965
	Bear Wallow	16010203	Cache	1999
	Beaver Creek	16010203	Cache	1966
	Dry Lake	16010203	Cache	1937
	Garden City	16010201	Rich	1950
	Lake Mary	16010203	Cache	1980
	Lakota	16010201	Rich	1926
	Little Rock Spring	16010203	Cache	2004
	Logan	16010203	Cache	1920
	Logan Canyon	16010203	Cache	1965
	Minnie Ann Springs, Logan Canyon	16010203	Cache	1958
	Swan Creek	16010201	Rich	1921
	Temple Fork	16010203	Cache	1999
	Temple Fork Ponds	16010203	Cache	2004
	Elk Wallow Pond	16010203	Cache	2004
	Tin Cup Springs	16010203	Cache	2004
	Tony Grove Lake, Logan Canyon.	16010203	Cache	1987
	Tony Grove+A62 (7000')	16010203	Cache	1965
	Tremonton	16010204	Box Elder	PRE-1931
	Wellsville Canyon	16010203	Cache	1926

Monte Cristo Range	Arbs Basin ponds	16010203	Cache	2005
	Birch Creek	16010101	Rich	2005
	Blacksmith Spring	16010203	Cache	2005
	Blind Spring	16010203	Cache	1998
	Buck Spring	16010203	Cache	2005
	Deer Pond	16010203	Cache	2004
	Elmo Spring	16010203	Cache	2001
	Lewis Spring	16010101	Rich	2004
	Lower Davenport Reservoir	16010203	Cache	1997
	Pond south of Walton Gulch	16010101	Rich	2005
	Red Rock Spring	16010101	Rich	2005
	Red Wells	16010203	Cache	1996
	Running Water Springs	16010203	Cache	1998
	unnamed spring, near Roundup Spring	16010203	Cache	2001
	Swan Spring	16010101	Rich	2004
	Sprout Spring	16010101	Rich	2003
	Hidden Spring	16010101	Rich	2005
	Sheep Creek	16010203	Cach	2004
	Middle Davenport Reservoir	16010203	Cache	2004
	Six Bit Spring	16010101	Rich	2004
	Boundary Spring	16010203	Cache	2004
	Walton Gulch ponds	16010101	Rich	2001
	Zion Spring	16010203	Cache	2004
Wasatch Range	1 mile southwest of Daniel's Summit	16020203	Wasatch	1959
	4 miles north of Nephi	16020201	Juab	NO DATE
	Alta	16020204	Salt Lake	1985
	American Fork Canyon	16020201	Utah	1937
	Aspen Grove, Mt. Timpanogos.	16020203	Utah	1937
	Big Cottonwood Canyon (9700')	16020204	Salt Lake	1962
	Bountiful	16020102	Davis	1912
	Brighton	16020204	Salt Lake	1990
	Bryant's Fork (lower)	14060004	Wasatch	2002
	Canyon, 3MI. NW Strawberry Reservoir	14060004	Wasatch	1934
	Daniel's Summit	14060004	Wasatch	1959
	East Canyon Reservoir	16020102	Morgan	1992
	Echo	16020101	Summit	NO DATE
	Fort Douglas+A154	16020204	Salt Lake	1909
	Goshen Bay	16020201	Utah	NO DATE
	Great Salt Lake	16020204	Salt Lake	1931
	Heber City	16020203	Wasatch	1960
	Mountain Dell Reservoir	16020204	Salt Lake	1960
	Mud Creek-below paved rd	14060004	Wasatch	2002
	Kimballs Junction (near Park City)	16020102	Summit	1913
	Lake Creek	16020203	Wasatch	1988
	Mineral Fork	16020204	Salt Lake	1981
	Mount Timpanogos	16020203	Utah	1937
	Nephi	16020201	Juab	NO DATE
	Provo	16020203	Utah	NO DATE
	Ray's Valley	16020202	Utah	1976
	Red Butte Canyon	16020204	Salt Lake	1932
	Red Pine - Maybird Ridgeline	16020204	Salt Lake	1985
	Sage Creek Bay	14060004	Wasatch	2001
	Salt Lake City	16020204	Salt Lake	1979
	Silver Lake at Brighton	16020204	Salt Lake	1924
	Silver Lake P.O.	16020203	Wasatch	1943
	Spring near campground	14060004	Wasatch	2002
	Strawberry Reservoir	14060004	Wasatch	2003
	Strawberry Reservoir Ranger Station	14060004	Wasatch	1950
	Vivian Park	16020203	Utah	1961
	Wanship	16020101	Summit	1915
	Wasatch Mountains, Provo Canyon	16020203	Wasatch	1913
	Little Cottonwood Canyon	16020204	Wasatch	1913
	Weber River Devil's Slide	16020102	Morgan	1915
	Wolf Creek Summit	16020201	Wasatch	1970

Uinta Mountains	1 mile east of Lost Lake	14060003	Summit	NO DATE
	Bear River, Hayden Fork on Stillwater	16010101	Summit	1931
	Bourbon Lake	16010101	Summit	1976
	Bridger Lake	14040107	Summit	1970
	East Fork of Bear River	16010101	Summit	2005
	East Fork of Smith's Fork	14040107	Summit	1994
	Elk Lake	16020203	Summit	1947
	Fish Lake	16020101	Summit	PRE-1931
	Hayden Fork	16010101	Summit	1931
	Hayden Peak	16010101	Summit	1970
	Holiday Park	16020101	Summit	NO DATE
	Lake G-51	14040107	Summit	1990
	Lake G-60	14040107	Summit	1963
	Lost Lake	16020203	Wasatch	NO DATE
	Lyman Lake	14040107	Summit	1975
	Mill City Creek	16010101	Summit	2005
	Naturalist Basin	14060003	Duchesne	1982
	Nobletts Creek	16020203	Wasatch	1960
	Northwest of Hayden Park	14060003	Summit	1970
	Soapstone Basin	16020203	Wasatch	1960
	Porcupine Ridge	16020101	Summit	1931
	Slate Gorge	16020203	Summit,Wasatch	1960
	Road Hollow	16010101	Summit	2004
	Mill Creek	16010101	Summit	2003
	Whitney Reservoir Area	16010101	Summit	2005
	Yellow Creek	16010101	Summit	2005
	Soutwest of Hayden Park	16010101	Summit	1970
	Spirit Lake	14040106	Daggett	1958
	Uinta Mountains	14040106	Daggett	1941
	Utah Retriever Trial Site	16010101	Summit	1996
	Washington and Trial Lakes	16020203	Summit	PRE-1931
	Weber River	16020101	Summit	1971
	Wolf Creek Summit	14060003	Wasatch	1970
Wasatch Plateau	Ephraim	16030004	Sanpete	1929
	Fairview	16030004	Sanpete	1939
	Juab	16030005	Juab	1889
Book Cliffs	Carbon-Utah Co. line near Kyune	14060007	Utah	NO DATE
	3 miles west of Colton	14060007	Utah	1932
	Boulger Creek	14060009	Emery	1950
	Colton	14060007	Utah	1932
	Forks of Boulger Creek & Huntington	14060009	Emery	1950
	Helper	14060007	Carbon	NO DATE
	Kyune	14060007	Utah	NO DATE
	Price	14060007	Carbon	1938
Tushar Mountains	Beaver River near Beaver	16030007	Beaver	1960
Sevier Plateau	Annabella timber sale	16030003	Sevier	2000
	Bagley Meadows	16030003	Sevier	2001
	Barney Creek	16030003	Piute	1997
	Barney Lake	16030003	Piute	2001
	Big Lake	16030003	Sevier	2001
	Deep Lake	16030003	Sevier	2000
	Doxford Creek	16030003	Sevier	2001
	Dry Creek	16030003	Piute	2000
	Dry Creek Guard Station	16030003	Piute	2001
	East Fork Manning Creek	16030003	Piute	1998
	Hunt''s Lake	16030003	Sevier	2001
	Koosharem Creek	16030003	Sevier	2001
	Koosharem Guard Station	16030003	Sevier	2000
	Little Meadows area	16030003	Piute	2001
	Lower Barney Lake	16030003	Piute	2001
	Magelby Reservoir	16030003	Sevier	2001
	Manning Creek	16030003	Piute	2001

Sevier Plateau - *continued*	North Fork Greenwich Creek	16030002	Sevier	2001
	Manning Meadows Reservoir	16030003	Piute	2001
	Manning/ Barney Confl.	16030003	Piute	2001
	Monkey Fork	16030003	Sevier	2001
	Monroe Creek	16030003	Sevier	2001
	North Fork Box Creek	16030002	Piute	2000
	South Fork Greenwich Creek	16030002	Sevier	2000
	South of Annabella Res.	16030003	Sevier	2000
	South of Annabella Res.	16030003	Sevier	2000
	South Fork Box Creek	16030002	Piute	2000
	Thurber Fork	16030002	Sevier	2001
	Timber sale	16030003	Sevier	2001
	Vale Creek	16030003	Piute	2001
	West of Annabella Reservoir	16030003	Sevier	2000
Awapa Plateau	Baker Spring	14070003	Wayne	2001
	Bicknell	14070003	Wayne	1930
	East Fork Boulder Creek	14070005	Garfield	1960
	East of Deep Creek Lake	14070003	Wayne	2000
	Fruita	14070003	Wayne	1938
	little pond by Unit 5	14070003	Wayne	2000
	Loa	14070003	Wayne	1937
	Lower Pine Creek Reservoir	14070003	Wayne	1997
	Pine Creek	14070003	Wayne	1997
	Pond 2 east of Neff Reservoir	14070003	Wayne	2001
	Pond 3 east of Neff Reservoir	14070003	Wayne	2001
	Pond 4 south of Snow Lake	14070003	Wayne	2001
	Pond 5 east of Neff Reservoir	14070003	Wayne	2001
	Pond 5 south of Snow Lake	14070003	Wayne	2001
	Pond downstream	14070003	Wayne	2000
	pond northwest of Deep Creek Lake	14070003	Wayne	2000
	Proposed Timber sale	14070003	Wayne	2000
	Round Lake	14070002	Wayne	2001
	Seven mile Creek	14070003	Sevier	1938
	Snow Lake	14070003	Wayne	2001
	Snow Lake pond C	14070003	Wayne	2001
	Unit 5 seeps and springs	14070003	Wayne	2000
Hurricane Cliffs	Iron County	16030006	Iron	1872
Pine Valley Mountains	Grass Valley Reservoir	15010008	Washington	1932
Paunsagunt Plateau	East Fork Sevier River (1)	16030002	Kane	2001
	East Fork Sevier River (2)	16030002	Kane	2000
	East Fork Sevier River (3)	16030002	Kane	1998
	East Fork Sevier River (4)	16030002	Kane	1998
	East Fork Sevier River (5)	16030002	Kane	2001
	Left Fork Kanab Creek	16030002	Kane	1999
	Robinson Canyon	16030002	Kane	2001
	East Fork Sevier River (6)	16030002	Kane	2002
	East Fork Sevier River (7)	16030002	Kane	2000
	Sieler Creek	16030002	Piute	1998
	Skunk Creek	16030002	Garfield	1998
	Tropic Reservoir	16030002	Kane	1993
	Tropic Reservoir	16030002	Garfield	1994

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APPENDIX 1.

Amphibian Survey Data Sheet

AMPHIBIAN SURVEY DATA SHEET □ National Biological Survey, 4512 McMURRY AVE, FT. COLLINS, CO 80525-3400

(circle choice for shaded variables; supply value for others) (ver.6/10/94)

DATE	BEGIN TIME	END TIME	OBSERVERS

LOCALITY

STATE	COUNTY	MAP NAME	OWNER	ELEVATION (circle scale) M FT

T	R	S	SECTION DESCRIPTION	UTM ZONE	NORTHING (or LAT)	EASTING (or LON)

AMPHIBIAN AND/OR GARTER SNAKE SPECIES PRESENT (INDICATE NUMBERS IN CATEGORIES IF POSSIBLE)

CIRCLE METHOD AND INDICATE IF VOUCHER SPECIMEN WAS COLLECTED

SPECIES	ADULTS/JUVENILES	CALLING?	TADPOLES/LARVAE	EGG MASSES	METHOD:
		Y N			VISUAL/AURAL ID INHAND DIP NET/SEINE TRAPPED VOUCHER COLLECTED? YES NO
		Y N			VISUAL/AURAL ID IN HAND DIP NET/SEINE TRAPPED VOUCHER COLLECTED? YES NO
		Y N			VISUAL/AURAL ID IN HAND DIP NET/SEINE TRAPPED VOUCHER COLLECTED? YES NO
		Y N			VISUAL/AURAL ID IN HAND DIP NET/SEINE TRAPPED VOUCHER COLLECTED? YES NO
		Y N			VISUAL/AURAL ID IN HAND DIP NET/SEINE TRAPPED VOUCHER COLLECTED? YES NO

FISH PRESENT?	YES ??? NO	FISH SPECIES:		
ENTIRE SITE SEARCHED?	YES NO	IF NO, INDICATE AREA	METERS OF SHORELINE M^2 OF HABITAT	

PHYSICAL AND CHEMICAL ENVIRONMENT (CHEMISTRY VARIABLES OPTIONAL - USE EXTRA SPACES FOR ADDITIONAL MEASUREMENTS)

WEATHER:	CLEAR	OVERCAST	RAIN	SNOW	WIND:	CALM	LIGHT	STRONG

AIR TEMP (circle scale) □C □F	WATER TEMP (circle scale) □C □F	COLOR:	CLEAR	STAINED	TURBIDITY:	CLEAR CLOUDY
pH	ANC					

SITE DESCRIPTIONS - (SKETCH SITE AND PUT ADDITIONAL COMMENTS ON BACK OF SHEET)
OMIT THIS SECTION IF DATA HAVE BEEN COLLECTED ON A PREVIOUS VISIT

ORIGIN:	NATURAL	MAN-MADE	DRAINAGE:	PERMANENT	OCCASIONAL	NONE

DESCRIPTION:	PERMANENT LAKE/POND	TEMPORARY LAKE/POND	MARSH/BOG	STREAM	SPRING/SEEP	ACTIVE BEAVER POND	INACTIVE BEAVER POND

SITE LENGTH (M)	SITE WIDTH (M)	MAXIMUM DEPTH:	< 1 M	1 □ 2 M	> 2 M

STREAM ORDER	1	2	3	4	5 +
PRIMARY SUBSTRATE:	SILT/MUD	SAND/GRAVEL	COBBLE	BOULDER/ROCK	OTHER

% OF LAKE MARGIN WITH EMERGENT VEGETATION:	0	1 □ 25	25 □ 50	> 50
EMERGENT VEGETATION SPECIES (LIST IN ORDER OF ABUNDANCE)				
NORTH SHORELINE CHARACTERS:	SHALLOWS PRESENT	SHALLOWS ABSENT	EMERGENT VEG PRESENT	EMERGENT VEG ABSENT
DISTANCE (M) TO FOREST EDGE	FOREST TREE SPECIES:			

APPENDIX 2.

Recommended Disease Testing and Disinfection Protocols

USGS

Collection, Preservation & Mailing of Amphibians for Diagnostic Examinations

Amphibian Research & Monitoring Initiative
National Wildlife Health Center
ACUC Tracking No. 2001-007 STANDARD OPERATING PROCEDURE
ARMI SOP No. 105
Revised, 2 March 2001

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I. PURPOSE:

This Standard Operating Procedure (SOP) provides guidelines for selecting, collecting, preserving and mailing amphibians. Also included are biosecurity recommendations for cleaning and disinfection of equipment, clothing, and vehicles in the field to prevent spread of potentially lethal infectious diseases of amphibians.
This SOP replaces National Wildlife Health Center ACUC Protocol 1997-04.

II. SCOPE:

This SOP covers all life stages of frogs, toads and salamanders (eggs, tadpoles/larvae, and adults). This SOP applies to normal-appearing, live, sick and dead amphibians.

III. EQUIPMENT & SUPPLIES:

A. Picnic cooler or styrofoam-lined cardboard box
B. Ice packs

C. Plastic bags (heavy mil), "zip-lock" bags, plastic food-container boxes
D. Packing foam, crumpled newspaper, bubble-wrap, etc.
E. Labels for containers
F. Tape: nylon-reinforced tape or wide clear wrapping tape

IV. BACKGROUND:

The best diagnostic specimen is the live sick amphibian.. Live amphibians are necessary to obtain meaningful bacterial cultures and most types of fungus cultures. In addition, blood for various "blood tests" can be obtained only from live amphibians. Dead amphibians have limited usefulness because aquatic animals decompose much more rapidly than terrestrial animals which means amphibian carcasses nearly always will have large numbers of decompositional bacteria and fungi throughout their bodies. This rapid decomposition (autolysis) makes it very difficult to obtain meaningful or useful bacterial and fungal cultures, but dead amphibians may still have usefulness for virus cultures, histology and toxicological tests, if promptly and properly preserved

If the amphibians will be captured and euthanized as part of other studies, then first observe and record their behavior. Blood should be collected and saved prior to euthanasia. If the euthanized amphibians will be preserved in a fixative, then collect swabs for bacterial, viral and fungus cultures from the mouth, vent, skin, and skin abnormalities ("lesions") prior to emersion of the animal in the fixative.

At a casualty site, the priority specimens for diagnostic examinations are live, sick amphibians. Divide dead amphibians into two groups: promptly preserve about half the carcasses (preferably the most recently dead amphibians) in 10% formalin (or 70-75% ethanol); promptly freeze the other dead amphibians (for virus cultures and possible poison tests). In cases involving less well known species, submission of live healthy amphibians as "control" or "baseline" specimens will be necessary to assist in the interpretation of findings in the sick or dead animals. More than one lethal disease may affect a population simultaneously, so submission of multiple animals is always encouraged. Collect specimens that represent the species that are affected and the geographic areas. Do not place live and dead animals in the same container, and do not put multiple species in the same container (except, it is acceptable to put dead animals of multiple species in one container of formalin or ethanol).

If possible, submission of invading (alien or introduced) amphibians from the casualty site is desirable, even if they appear healthy or unaffected, because invasive species can be the vectors of infectious diseases. If any other endemic amphibians, fish or reptiles are present at the casualty site, these animals also may need to be examined as part of a wider epizootiologic investigation into the cause of the casualties.

Many amphibian die-offs are fleeting. This means the casualties must be collected the hour and day they are found. Returning to the casualty site the next day to collect sick amphibians and carcasses invariably fails because of the highly efficient activity of scavengers during the night and rapid autolysis of carcasses.

V. METHODS:

A. Live & Sick Amphibians

1. Eggs. Place eggs in heavy mil plastic bag or plastic container. Equal volumes of air and water should be present in the bag or container to assure adequate oxygen exchange. Do NOT fill bags or containers completely with water. If bottled oxygen is available, it may be placed into the air cell in the bag or container, but this is optional. If possible, place plastic bags in a solid container for support and to avoid crushing specimens or puncture of the bag.

2. Tadpoles, Larvae & Neotenes. Same as for eggs. For small amphibians (<2 grams each), multiple live animals may be placed in one container, but avoid mixing species. For larger aquatic larvae and neotenes, one animal per bag or container is recommended. It is important to assure enough air is present in each container; containers that have a large surface area of water to air are preferred; hence, flat food storage-type plastic boxes with lids (available at nearly any grocery store) are preferred to tall narrow plastic bottles. If bottled oxygen is available, oxygen may be placed into the air cell in the bag or container, but this is optional.

3. Adult amphibians (terrestrial amphibians). Plastic boxes or bottles with wide lids may be used for mailing. Sick

amphibians should be mailed in separate containers. Two or more live adult amphibians of the same species may be placed in one container, but avoid crowding. Note: if an infectious disease is the cause of the casualties, the disease may be transmitted between amphibians in the container, if more than one animal is placed in each container. Wet unbleached (brown) paper towels or wet local vegetation should be added to the container to prevent dehydration of the animal; do not use sponges, because many contain chemicals that are toxic to amphibians. Three or more small holes should be made in the lid of each container. Plastic bags are not recommended for terrestrial amphibians.

B. Dead Amphibians

1. About half the dead amphibians should be immediately placed into 10% buffered neutral formalin or 75% ethanol for histologic examinations. When possible, the freshest carcasses (those with the least amount of decomposition) should be selected for fixation. Prior to immersing the carcass in the fixative, slit open the body cavity along the ventral midline to assure rapid fixation of internal organs. For the first 3-4 days of fixation, the volume of fixative to volume of carcasses should be 10:1. After 3-4 days of fixation, the carcasses may be transferred to a minimal amount of fresh fixative that prevents drying of the specimen.

2. Freezing. About half the carcasses should be promptly frozen. Preferred freezing temperature is -40 degrees, but any freezing temperature is preferable to a chilled carcass. Do NOT freeze amphibians in water. Frozen carcasses can be used for virus cultures, toxicological examinations, and molecular (DNA) tests. Frozen and preserved carcasses are not suitable for bacterial and fungus cultures; generally, bacterial and fungus cultures will be attempted only on amphibians that are submitted live.

3. Decomposed carcasses. Clearly decomposed carcasses may have some diagnostic usefulness for molecular testing and toxicological analyses. Very decomposed carcasses with fluffy growths of fungus on the skin; maggots in the mouth, vent and body cavity; or those that consist of just skin and bones, should be frozen and saved, if fresher carcasses are not available.

C. Labels

Each container must be labeled. Paper labels written in pencil are preferred, especially if there is ethanol in any containers. Most ink will dissolve in ethanol or become streaked during freezing and thawing. Each label should have the following information:

•species •date collected
•location (state/county/town) •found dead or euthanized
•collector (name/address/phone) •additional history on back of tag

D. Mailing

1. Shipping container. Use a picnic cooler or styrofoam-lined cardboard box.

2. Ice. Ice packs ("blue ice") is preferred to wet ice to avoid leaking during shipment. Most amphibians from temperate climatic zones should be mailed with ice packs. Ice packs should be wrapped with about 5 layers of newspaper before being placed at the side of containers of amphibians. For live amphibians, position ice packs on the side of the shipping container, not under the specimens, as this allows live amphibians to move away from cold zones.

3. Frozen specimens. Frozen samples should be mailed with dry ice. Ice packs are an alternative, especially if the ice packs were frozen in an ultra-low freezer (-40 or lower). Avoid mailing frozen specimens in the same shipping container as live animals or specimens in formalin. If frozen samples and live amphibians (or specimens in formalin) must be mailed in the same shipping container, never put dry ice in the shipping container. If frozen samples and live amphibians (or specimens in formalin) must be mailed in the same shipping container, separate the shipping container into two compartments with styrofoam panels and place the ice packs at one end of the container next to the frozen samples.

4. Preserved specimens. Once specimens have fixed in a large volume of formalin or ethanol for 3-4 days, the preserved samples may be mailed in a minimal amount of preservative that prevents drying. It is not necessary to mail large volumes of liquid fixative. Preserved carcasses may be wrapped in gauze or a paper towel that is moistened with the fixative. If preserved specimens are transferred to plastic bags, always double bag the specimen and pack it into the shipping box so as to avoid crushing of the sample during transport.

5. Packing the shipping container. Plastic boxes and bags containing live amphibians may be stacked, but keep air holes clear; some plastic boxes will stack tightly on each other and may seal air holes of lower containers. Do not place live amphibians directly on top of ice packs, because this may cause water in the animal's container to freeze. After placing ice packs and specimen containers in the shipping box, add crumpled newspaper, plastic peanuts, or other filler around the containers to minimize shifting of contents during mailing and crushing of samples in plastic bags. If a styrofoam-lined cardboard box is being used for mailing, then line the box with a heavy mil plastic bag and place all ice packs and specimens into the bag in order to minimize leaks and moisture condensation into the cardboard box.

6. Double bagging. Frozen samples and specimens in formalin (or ethanol) should be double bagged. This is especially important to avoid leakage of fixatives. If glass vials or jars must be mailed, these too should be placed into a plastic bag.

7. Taping. Tape should be wrapped completely across the lid, sides and bottom of each plastic cooler in at least two places to prevent accidental opening of the container during mailing. Nylon-reinforced tape is recommended, but 2-inch wide clear tape also may be used.

8. Overnight couriers should be used for sick, live and frozen amphibians.

9. Dates for Mailing. Only mail boxes of specimens by overnight couriers on Mondays, Tuesdays and Wednesdays. Most diagnostic laboratories are not open on weekends, so specimens mailed on Fridays may be held in delivery vans in hot weather over the weekend. A significant percentage of packages mailed by overnight courier on Thursdays, do not arrive in 24 hrs, and these also may be held over the weekend in freezing or very hot delivery vans.

10. Mailing. Overnight courier service should be used. Securely tape the cooler or box and mail to:

National Wildlife Health Center
6006 Schroeder Road
Madison WI 53711

Note: in addition to the NWHC address, you need to add DIAGNOSTIC SPECIMENS-WILDLIFE to the outside of the box. This label will direct coolers with specimens to our necropsy entrance. Do not label the container with statements like, "Live Animals", as this usually causes problems for most couriers.
Contact NWHC (608-270-2400)(FAX 608-270-2415) prior to shipping animals by 1 day (overnight) service and after shipment to confirm the estimated time of arrival

VI. BIOSECURITY IN THE FIELD:

Biosecurity (prevention of the spread of infectious agents) must be considered at any site with dead and dying animals. Biosecurity involves three equally important aspects:
-- safety of the humans and scientists in the area
-- decontamination/disinfection of field equipment (especially boots and nets) to prevent spread of the possible infectious agent to other sites and other populations of animals
-- quarantine (isolation) of live sick animals from all other populations in the field and in laboratory animal colonies

A. Human safety

1. Toxic Spills. Note whether there are sick and dead animals of more than one vertebrate class and phyla (ie, dead birds, frogs, fish, snails, insects, etc); if so, then there is a much greater chance the animal deaths are due to a toxin

(poison), and use utmost caution in entering the area, because mammals (ie, the field scientists) could also be poisoned.

2. Personal Hygiene. Few infectious diseases of amphibians are contagious to humans. The best known infectious diseases that may be carried by amphibians are enteric (gut) pathogens, such as salmonella and yersinia bacteria.
a. Disposal latex gloves should be worn when handling sick and dead amphibians.
b. Inverted plastic bags can be placed on the hand to grasp a sick or dead amphibian, and then the bag can be sealed around the animal.
c. Wash hands thoroughly with soap and water after handling any live or dead amphibians.

3. Skin Toxins from Amphibians. The skin secretions of many amphibians contain potent irritants and toxins. In the United States, endemic newts and toads and the introduced giant toad (Bufo marinus) have toxic skin secretions. In toads, it is best to avoid touching the parotid glands. After handling amphibians, avoid touching your eyes and mouth. Skin secretions of certain western newts are known to cause temporary blindness lasting several hours in humans if the secretions get into the eyes. The parotid secretions of giant toads, if ingested, can rapidly cause heart disease in humans and pets. Again, always throughly wash your hands after handling amphibians.

B. Washing & Disinfecting Equipment

If only amphibians (or only amphibians and fish) are affected at a casualty site, there is a greater likelihood the deaths are due to an infectious disease; it would then be important to wash and disinfect all field equipment that came into contact with animals and surface waters (ie, boots, rubber gloves, nets, minnow traps, tripods, water quality instruments, etc); this may also include tires and wheel wells of vehicles that drove through surface waters at the site.

1. Washing vs Disinfection. Washing and disinfecting are two different procedures. Washing involves the use of a solvent (water) or soap to clean off chunks of mud and debris. Disinfection follows washing, and involves use of a chemical to kill micro-organisms. Because no disinfectants are also a soap (or detergent), and no disinfectants can penetrate chunks of mud and debris, disinfection is done only after the objects have been washed.

2. Soaps. Use only water to wash off mud and debris, or use a biodegradable soap and water. Never discard soaps or detergents into surface water; many are toxic to amphibians, fish and invertebrates.

3. Disinfectants. The disinfectant of choice is bleach (sodium hypochlorite). Disinfection is easily accomplished by putting 4 ounces of bleach (half cup) in one gallon of clean water and using this solution to rinse off all field equipment prior to going to another site. For this disinfection process, a long handled brush and 5-10 gallon bucket should be considered standard equipment for field investigators and when visiting casualty sites. Bleach is the disinfectant of choice because it is the least hazardous chemical for disposal, and it decomposes rapidly in the environment. Other disinfectants are available, but these may contain iodine or phenols which are not biodegradable and are much more persistent in the environment.

4. Procedure. Objects are first washed with a biodegradable soap to remove obvious chunks of mud and vegetation, especially that which may be trapped in the tread of boots. If soap is used in the washing step, then it should be rinsed off with clean water. Then the objects are completely immersed in the disinfectant solution or completely wetted with the solution. The solution is allowed to air dry (Note: the disinfectant solution should NOT be rinsed off.)

C. Quarantine of amphibians

Amphibians (dead or alive) from a casualty site should be considered contagious specimens. Live sick animals and carcasses should never be released or discarded at other sites and should not be taken into laboratory settings with other live amphibians, fish or reptiles. Release of sick amphibians or discarding carcasses at other sites may result in the spread of infectious diseases.

D. Carcass Disposal

It is recommended that all dead amphibians, and as much as possible, other dead animals (fish, birds, reptiles, etc), be collected into plastic trash bags (preferably double bagged) and disposed by burial or incineration. Removal of carcasses may slow the spread of infectious diseases that caused the die-off, and may prevent a subsequent outbreak of botulism. As part of the normal decomposition process, many carcasses will support the growth of the bacterium, Clostridium botulinum; this bacteria produces an extremely potent toxin that can cause botulism; maggots are resistant to botulism, but one maggot, which can be a very attractive prey item to an amphibian or bird, may contain enough botulinum toxin to kill an animal.
